Newport Research Facility

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NO. 58

Report for the year ended 31st December 2013

This report follows in sequence from the Annual Reports of the Salmon Research Agency of Ireland Inc. and the Salmon Research Trust of Ireland Inc.

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Summary

1. The Salmon Research Agency of Ireland merged with the Marine Institute on the 1st July 1999 into Aquaculture & Catchment Management Services and in 2010 the group merged with Fisheries Ecosystem Advisory Services. This report provides a continuation of the data records for the Burrishoole facilities.

2. The total rainfall recorded in Furnace in 2013 was 1391.8 mm. Months of relatively high rainfall in 2013 were January, April, May and December. Low rainfall was recorded in March, June, July, September and November. There were 13 days in June and 19 days in July where no rainfall was recorded.

3. The environmental programme was maintained in the catchment with the network of rain gauges, water level recorders and river and lake monitoring stations all in operation.

4. The total release of micro-tagged salmon smolts of Burrishoole reared origin into L. Furnace amounted to 33,912. Smolts were released as six core and two SLICE treated groups, ranging in mean weight from 53g to 64g. Smolts were released into Furnace on 7th May 2013. An additional experiment group of 10,605 smolts was also released derived from Delphi 2-seawinter parents.

5. In 2007, the Irish Government introduced a cessation of drift netting for salmon at sea and this was continued in 2013.

6. A total of 710 wild grilse and 15 previously spawned grilse (psg) were recorded moving upstream through the permanent traps during the season. The number of spring fish recorded was 23. The total run of wild grilse, including the Furnace rod catch (1), was 711 + 15 previously spawned grilse as determined by floy tag returns.

7. Returning adults were checked for net mark damage; 2.8% (n=747) of wild salmon (mainly in June, and in July, August and September) and 1.8% (n=1397) of reared salmon (in June, July and August) had net marks present.

8. The maximum spawning escapement was 691 wild and 11 reared fish.

9. A total of 6355 wild salmon smolts were recorded in the downstream trap in 2013. The wild return of 2012 smolts as wild grilse in 2013 was 9.4%. The ova to smolt survival at 0.66 – 0.75%.

10. Wild kelt survival was 53.9% and kelt return as previously spawned grilse later in the year was 4.5%.

11. The average return to fresh water of the Burrishoole reared grilse recorded was 2.9%, lower than the 4.89% recorded in 2012.

12. A total of 70 wild sea trout and a further 101 non-silvered trout migrated upstream through the traps in 2013. Of the sea trout, 20 were adults and 101 (71.4%) were finnock.

13. The 2013 sea trout smolt run amounted to 485 smolts.

14. The percentage of trout smolts returning as finnock in the same year has historically ranged from 11.4% to 32.4%. In 1989 it collapsed to a minimum of 1.5%. There has been a saw-tooth pattern of finnock return in the 1990's between 4 & 10%, rising to 16.7% in 1999. Finnock return in 2013 was 11.0%.

15. Silver eel trapping continued with the total run amounting to 3633 with the run mainly in October (68%).

16. A total of 106 salmon were caught in the Rod Fishery in 2013. The catch consisted of 35 wild fish and 71 reared salmon. One wild fish was killed on L. Furnace and the rest were returned alive. There were 30 sea trout reported caught on L. Furnace and ten on L. Feeagh and these were returned alive. 474 brown trout were also reported caught on L. Feeagh in 2013.

17. 2013 marked the completion of 23 years of catchment electrofishing surveys for juvenile salmonids and eel.

18. Eel fyke net surveys of Bunaveela, Feeagh and Furnace were undertaken in 2013. The data from these surveys were included in the National eel database.

19. *Anguillicoloides crassus*, the non-native swimbladder parasite of eel, was recorded in the saline waters of Lough Furnace for the first time in 2011 and again in 2012 and 2013. Infection intensity has increased year on year. It has not been observed to date in freshwater in Burrishoole. This is the first known introduction of an aquatic invasive species into Burrishoole.

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1 Introduction

This report represents a continuation of the scientific aspects of the Annual Reports published by the Salmon Research Agency of Ireland, now integrated them into the Fisheries Ecosystem Advisory Services Group (FEAS) of the Marine Institute. The data presented creates a unique record of fish rearing and wild fish census data for the past 43 years. This data is an essential component in the local, regional and national management of salmon, sea trout and eel and is becoming ever more valuable in the light of increasing pressures on natural stocks, such as exploitation, habitat degradation and global climate change scenarios. The fish monitoring facilities in Newport, along with the reared and ranched salmon stocks held in Burrishoole, are also essential for the evaluation of novel enhancement techniques, alternative stocks and ranching and evaluation of interactions between farmed, ranched and wild strains.

2 Environmental Data

2.1 Mill Race Data

2.1.1 Rainfall

Daily meteorological data were collected during 2013 at the manual Met Station in Furnace. The monthly rainfall figures for 2010, 2011, 2012 and 2013 are given in Table 2.1, along with the annual totals for the years 1977 to 2013. Months of relatively high rainfall in 2013 were January, April, May and December. Low rainfall was recorded in March, June, July, September and November. There were 13 days in June and 19 days in July where no rainfall was recorded. The total rainfall was 1391.8mm in 2013. Daily rainfall amounts are shown in Figure 2.1.

Table 2-1: Monthly rainfall totals (mm) for the Furnace Station in 2010, 2011, 2012 and 2013 and the annual totals for 1977 to 2013.

Month	2010	2011	2012	2013	Year	Total	Year	Total
January	86.0	93.4	186.0	208.9	1977	1579.7	2000	1833.2
February	69.1	192.7	169.0	94.3	1978	1592.2	2001	1298.7
March	82.5	82.6	70.7	60.4	1979	1653.3	2002	1715.9
April	48.8	89.2	92.9	126.2	1980	1792.1	2003	1353.2
May	48.2	161.1	78.0	159.4	1981	1646.8	2004	1641.3
June	44.3	96.1	178.7	64.8	1982	1609.6	2005	1608.2
July	129.3	40.5	111.1	85.3	1983	1495.9	2006	1550.7
August	100.2	135.1	113.1	101.6	1984	1556.6	2007	1576.8
September	262.4	199.1	196.0	93.9	1985	1584.1	2008	1805.0
October	130.9	276.7	118.4	111.3	1986	1886.9	2009	1793.9
November	240.1	167.0	175.3	90.5	1987	1373.6	2010	1311.6
December	69.8	293.4	187.2	195.2	1988	1715.2	2011	1826.9
					1989	1583.9	2012	1676.4
Total	**1311.6**	**1826.9**	**1676.4**	**1391.8**	1993	1473.4	2013	1391.8
					1994	1757.1		
					1995	1382.5		
					1996	1286.6		
					1997	1351.6		
					1998	1830.9		
					1999	1949.1		

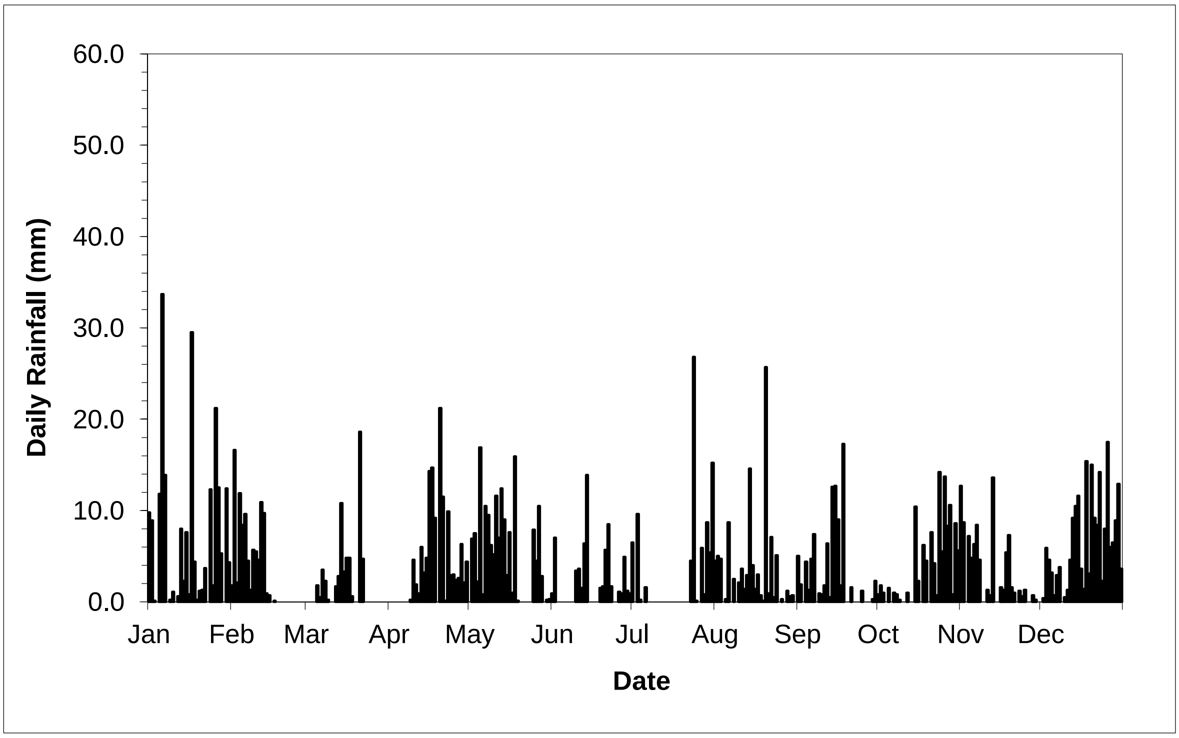


Figure 2-1: Daily rainfall amounts (mm) recorded in the Mill Race manual weather station in 2013.

2.1.2 Water Level and Temperature

Water Level: Difficulties were experienced in 2003 with the automatic water level chart recorder which had been in place since before 1970. An OTT Orphimedes automatic water level recorder was installed in late January 2004 and data from this sensor are presented here. Water levels are recorded every 15 minutes and are presented in Figure 2.2 recorded at 00:00 hrs.

The plot in Figure 2.2 shows two drought periods in the March April period. This was followed by two floods during the smolt run in April and May and a series of small floods throughout the summer, in spite of the relatively high air temperatures in June and July. A period of low water in October interfered with the timing of the silver eel run.

Water Temperature: In 2004, a TidbiT temperature logger was installed along with the chart recorder and this records water temperature every 30 minutes. In 2009, this was upgraded to an OTT Orpheus mini sensor and logger. The temperature logger data are presented in Figure 2.3, recorded at midnight.

In 2013, water temperatures (recorded at midnight) fell to a minimum of 4.9^{0}C on the 12th March. There was a fairly steady increase in temperature from mid-April until a sharp increase occurred in early June to a peak of 18.6^{0}C. This dropped back to 13^{0}C and then there was a further hot spell of weather which increased water temperature to a peak of 22.9^{0}C on the 12th July. Temperature remained high until early August. The temperature dropped fairly steadily from early August for the rest of the year to 6.4^{0}C at the end of December.

Note: A problem was encountered with the temperature TidBit data recorded from July 2010 to 2013. It was decided that the temperature data collected by the OTT Orpheus sensor at the same location was more reliable and the database will be update accordingly. The 2013 data presented in this report was collected by the Orpheus sensor.

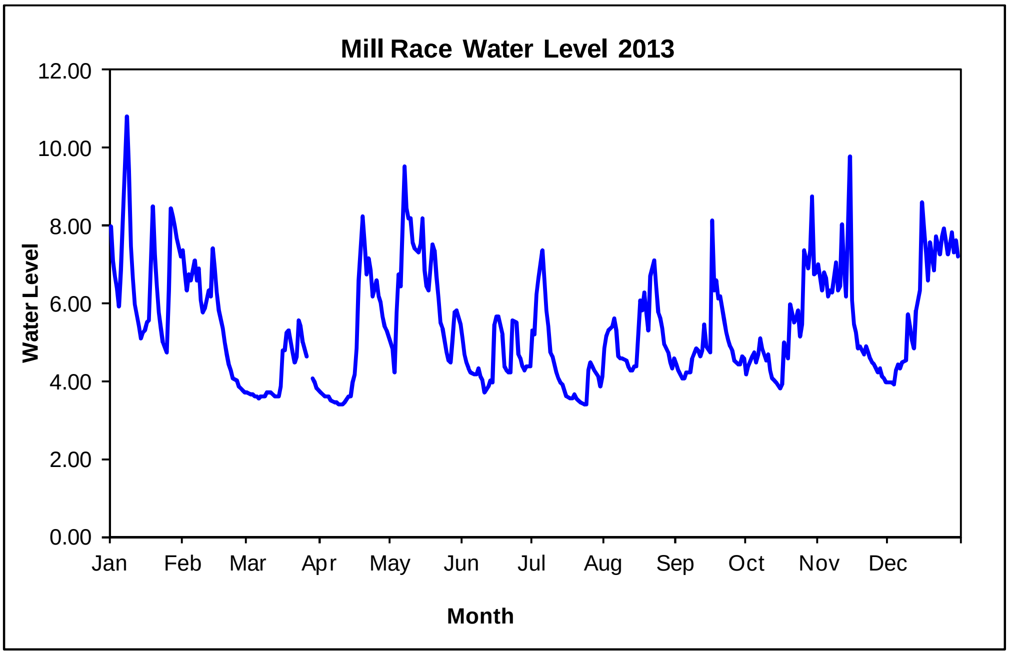


Figure 2-2: Water levels recorded at mid-night for the Mill Race using an OTT Orphimedes automatic water level recorder.

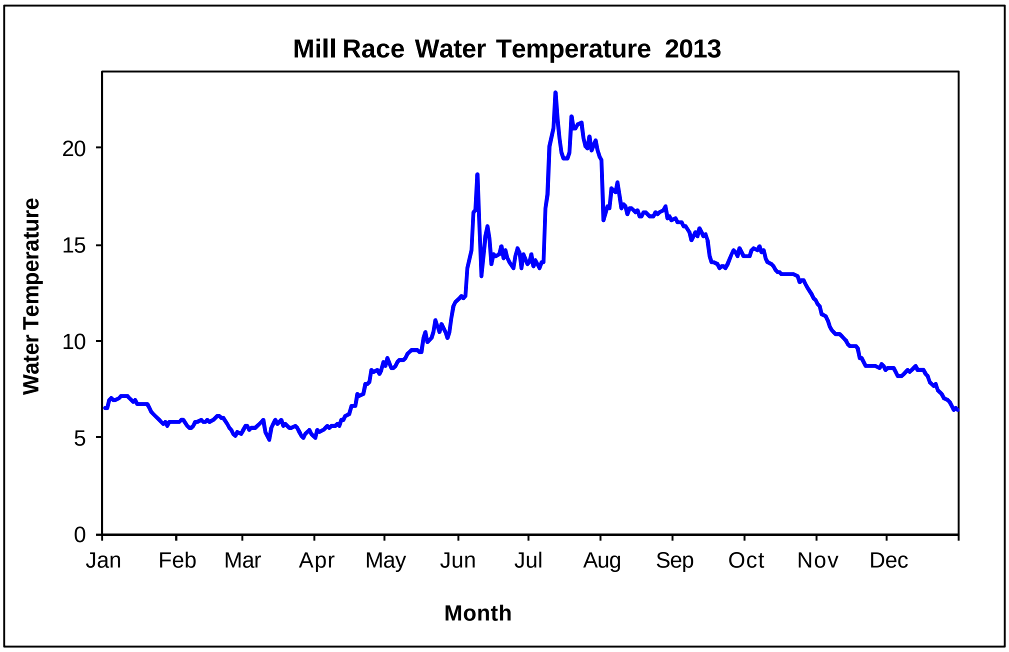


Figure 2-3: Water temperatures (°C) recorded, by OTT Orpheus mini sensor and logger, at mid-night for the Mill Race.

2.2 Catchment Programme

2.2.1 Background

Over the last twenty years, the Marine Institute has developed a monitoring programme in the Burrishoole catchment, with the aim of ensuring a long term ecological record against which changes in fish biology can be assessed. At the centre of the monitoring program are a series of automatic monitoring stations which measure key aquatic parameters at high frequency. These automatic stations include two lake stations (AWQMS), which have various meteorological instruments included with a suite of underwater temperature and water chemistry sensors, and three river stations, (ARMS), which are equipped with sensors for measuring water temperature, water level, pH, conductivity, dissolved oxygen, and turbidity. The automatic monitoring stations are also equipped with telemetry systems for relaying high-resolution data back to the laboratory. The data from the lake and river stations are complemented by spot samples analysed for water colour, turbidity, Total Phosphorus, Total Nitrogen and ethanol extracted chlorophyll *a*. In addition, the Institute has deployed core-funded instrumentation including temperature loggers, water level recorders and data-logging rain gauges in the Burrishoole, Owengarve and Owenduff catchments. These instruments allow high-resolution patterns of rainfall to be linked with stream flow. An important feature of the monitoring network is the ability to collect simultaneous data from river, lake, and climatic instruments.

In the last decade, the physical, chemical and meteorological data have been supplemented with biological datasets describing zooplankton and phytoplankton assemblages in Lough Feeagh and Lough Furnace, along with macroinvertebrate species occurrence and abundance from 16 index sites.

2.2.2 The 2013 Programme

The maintenance and development of long term physical, chemical and biological datasets characterising the freshwater component of the Burrishoole catchment continued in 2013. Regular downloads of remote equipment, as well as routine maintenance and replacement of broken equipment, were carried out at all sites. Considerable efforts were continued in 2013 to enhance the usability of the high frequency data, by development and maintenance of relevant rating curves and instrument calibration.

2.2.3 The Black River

The main river flowing into Lough Feeagh is the Black River, also known as the Shramore River. A water level recorder is installed approximately 500m above the lake. Figure 2.4 shows the average daily water level and Figure 2.5 shows the average monthly water levels from 2002 to 2013. It is immediately apparent that the last three years have been uncharacteristically wet, with water levels rarely dropping to base flow.

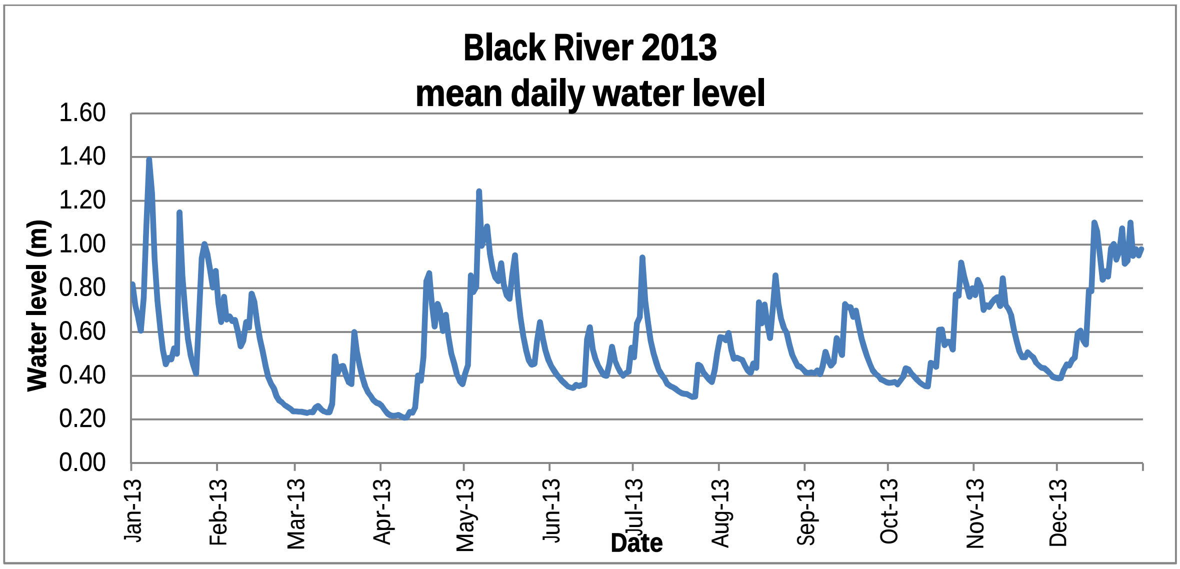


Figure 2-4: Mean daily water level for the Black River, 2013.

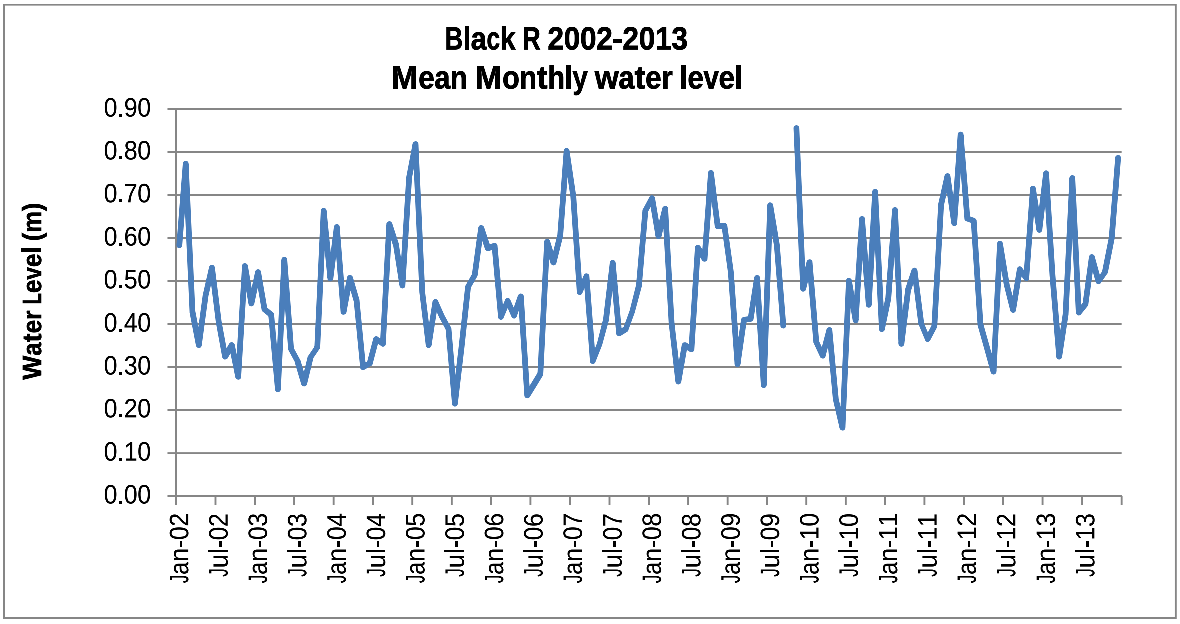


Figure 2-5: Monthly mean water levels for the Black River, 2002-2013.

2.2.4 Lough Feeagh

Lough Feeagh is situated in the Burrishoole catchment in the west of Ireland close to the Atlantic coast and is therefore strongly affected by the temperate oceanic climate that predominates in the region. The water is soft (pH range 6.6-7.8 in 2013) and highly coloured (2013 mean of 77 mgl^{-1} PtCo), and is oligotrophic, with Chlorophyll *a* ranging between 1 and 2µg l^{-1}. Mean annual Total Phosphorous is 8.6 µg l^{-1} (2012) and Total Nitrogen is 0.37mgl^{-1} (2012). The Lough Feeagh Automatic Water Quality Monitoring System (AWQMS) measures various parameters using a Hydrolab Datasonde 5, two Chelsea scientific minitrackas and a Seapoint fluorometer (pH, dissolved oxygen, temperature and conductivity, turbidity, Chl and CDOM fluorescence). These parameters are measured every two minutes and an hourly average is calculated for all the parameters. There is also a thermister chain and various weather instruments continually monitoring variables such as barometric pressure, wind speed and wind direction.

The Lough Feeagh AWQMS operated well in 2013, with only short time periods of missing data. Spring was relatively cold and the lake stratified later than normal (Fig. 2.6). Despite this cold spring, the epilimnetic temperatures in 2013 were warmer than any of the previous years on record (Fig. 2.7).

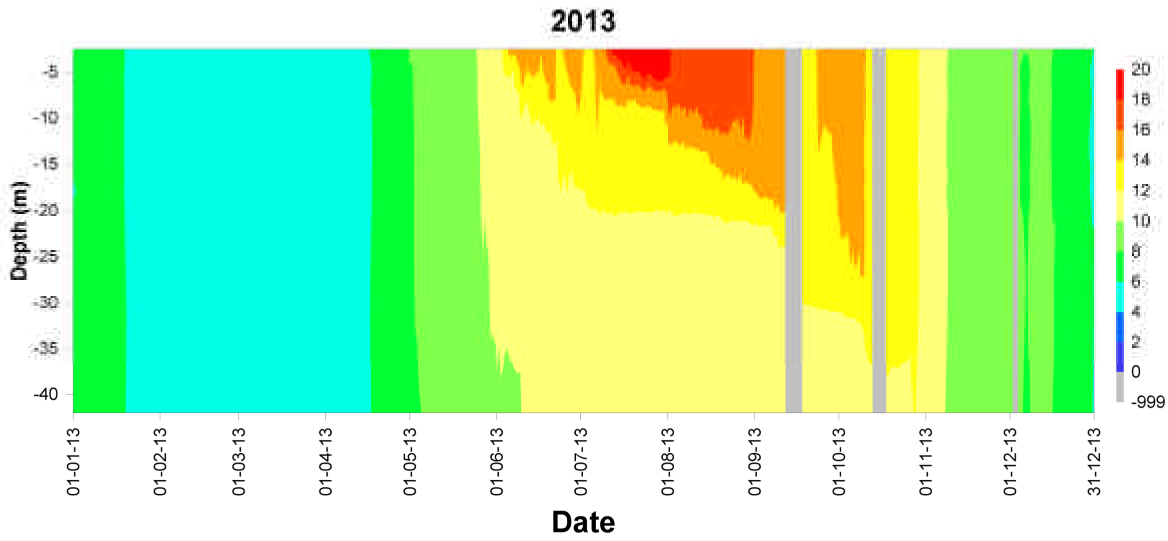


Figure 2-6: Temperature profile for L. Feeagh measured using PRT sensors on the AWQMS for 2013. The grey denotes missing data.

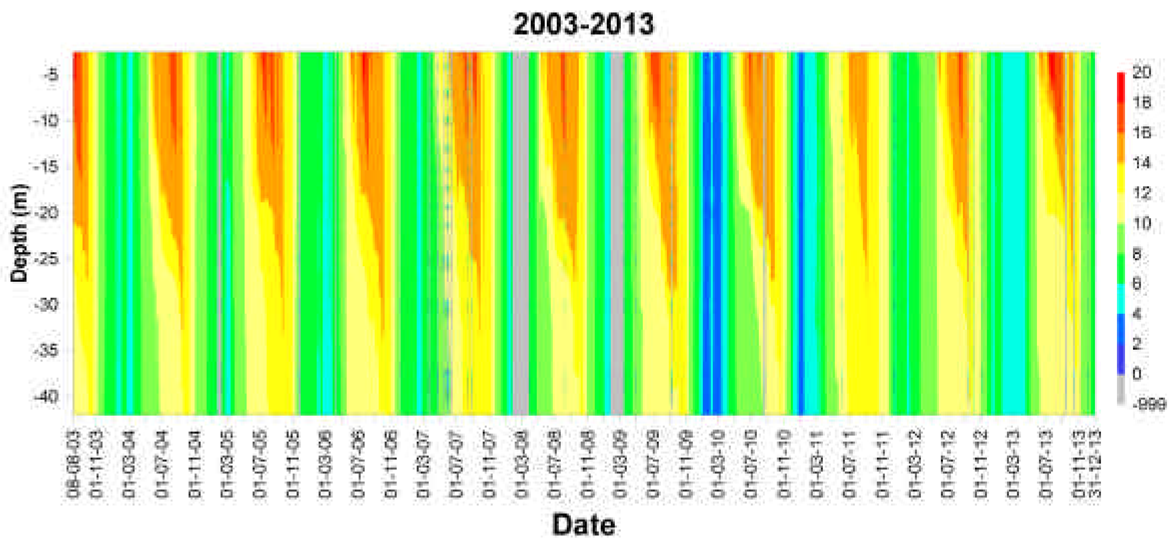


Figure 2-7: Temperature profiles for L. Feeagh measured using PRT sensors on the AWQMS for 2003-2013. The grey denotes missing data.

2.2.5 Lough Furnace

Lough Furnace is situated in the lower end of the Burrishoole catchment. Lough Furnace, (2km from north to south at its widest point, covering an area of 170ha, max depth is 21m with an average depth of 7m) is a cryptodepression tidal lagoon lake. Sea water enters the lake during spring tides but the freshwater exchange ensures relativity low salinities at the surface throughout the year. The lough is thermally stratified throughout the year with spring and autumn inversions and accompanying halo- and oxyclines. Monitoring of L. Furnace commenced in the early 1970s and automatic daily monitoring commenced in May 2008. This AWQMS (Fig. 2.8) has a Datasonde DX5 attached to a profiling winch, enabling temperature, conductivity, dissolved oxygen (% and mg/l), salinity and pH profiles of the lake to be taken. The winch profiles the lake 4 times a day (6am, noon, 6pm and midnight), taking four hours to run a profile and is parked for two hours. There is also a nephelometer and fluorometer positioned one meter below the water column. All parameters are measured every two minutes and an hourly average is then calculated. A weather station is also fully functional on the AWQMS measuring wind direction, wind speed, radiation, relative humidity and barometric pressure.

Figure 2-8: The Automatic Water Quality Monitoring Station (AWQMS) on L. Furnace (left) and the meteorological instruments attached (right)

Lough Furnace exhibited anoxia below 5 metres for most of 2013. The dissolved oxygen in the hypolimnion was replenished at the end of April, coinciding with the breakdown of the winter inverse temperature stratification, and the formation of the summer temperature stratification. This was probably not the result of a complete mixing of the water column, as the salinity profile indicates a strong halocline throughout the year. Instead, a very high tide, coupled with low freshwater inputs at the end of April probably enabled water from Clew Bay to reoxygenate the hypolimnion (Fig. 2.9-10). The main algal productivity occurred just above the halocline during the spring and summer (Fig. 2.10).

Five complete years of continuous data from the AWQMS on Lough Furnace have now been collected, and show that there have been two instances of refreshing of the hypolimnion with oxygenated water (March 2010 and April/May 2013) (Fig. 2.11). Similar to Lough Feeagh, the summer temperatures of 2013 in the epilimnion were considerably warmer than previous years, despite the cold spring (Fig. 2.11). When taken in the context of several years data, it can now be seen that the deep freshwater layer over the winter of 2011/2012 (when the halocline persisted around 6 metres) appears to be the exception, and the halocline is generally present at around 4 metres or less (Fig. 2.12). Finally, the Chlorophyll fluorescence indicates a strong spring bloom in 2013, and similar to other years, the main biomass of algae appeared to occur in the mixed layer between the hypolimnion and epilimnion (Fig. 2.12).

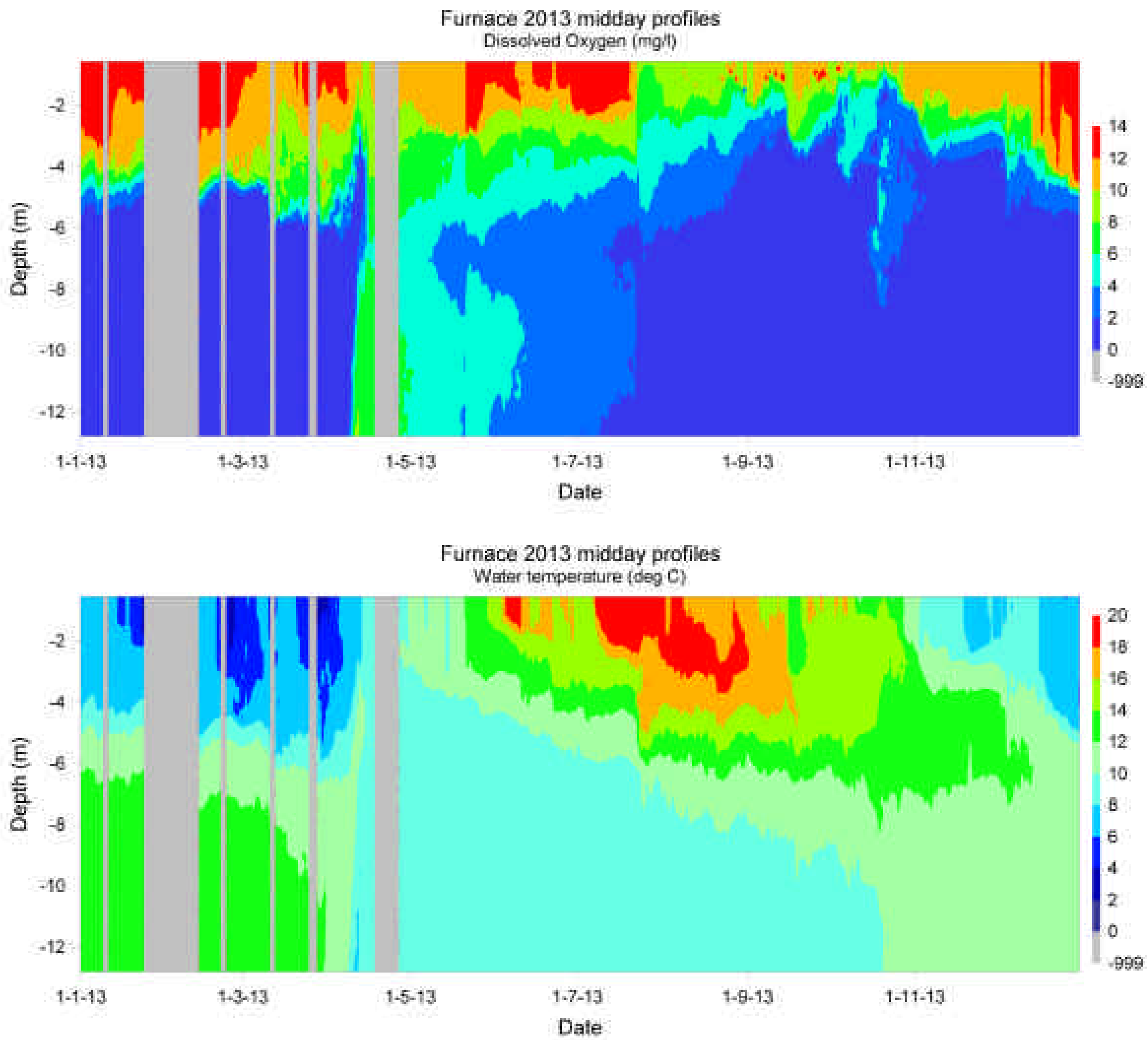
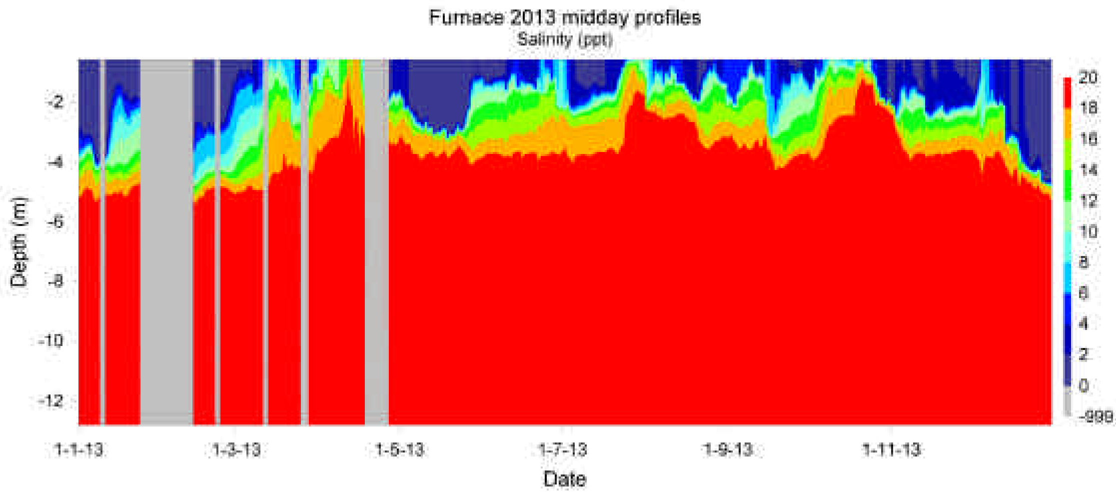


Figure 2-9: Oxygen (top) and temperature (bottom) profiles from Lough Furnace, 2013. Grey indicates missing values.



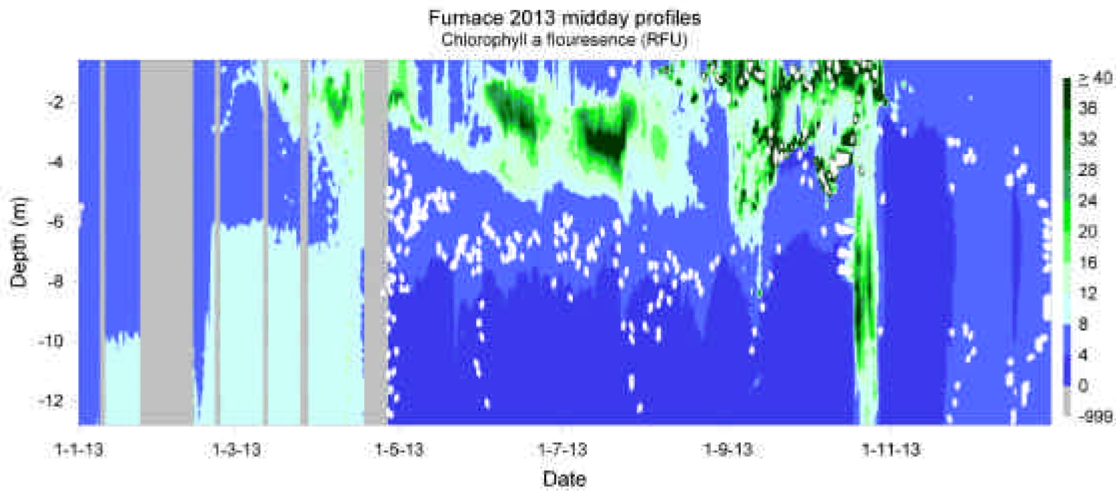


Figure 2-10: Salinity (top) and Chlorophyll *a* (bottom) profiles from Lough Furnace, 2013. Grey indicates missing values.

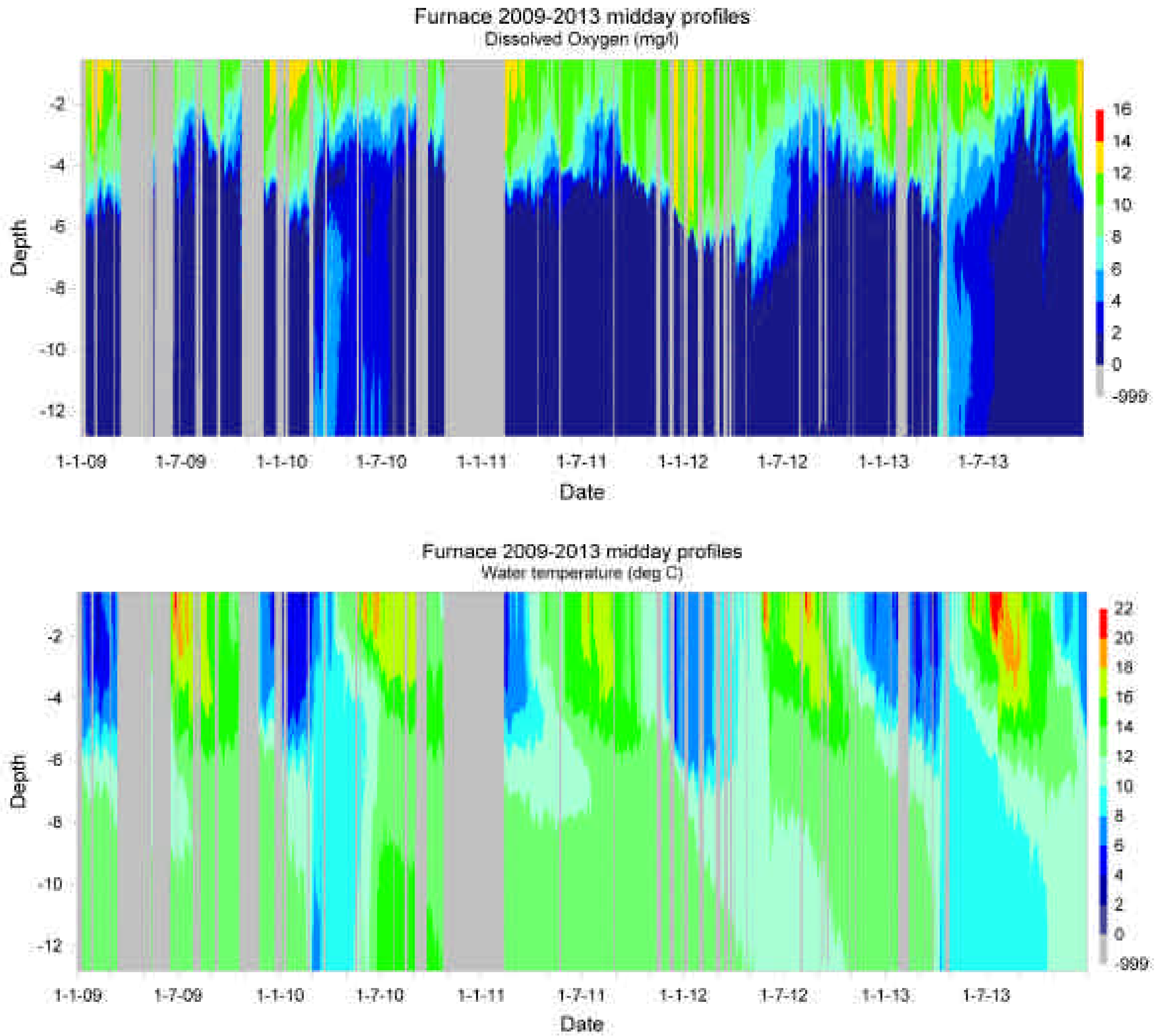
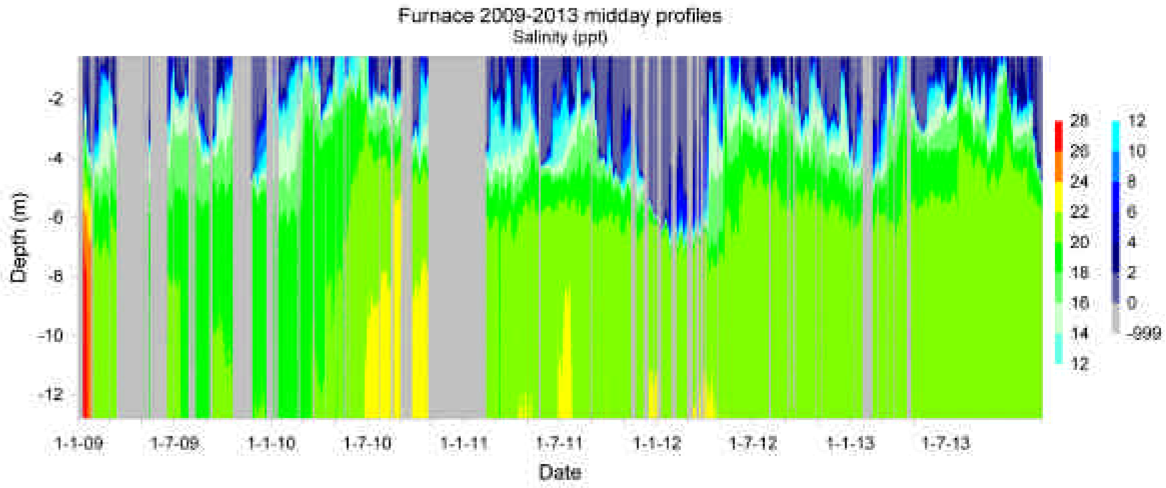


Figure 2-11: Oxygen (top) and temperature (bottom) profiles from Lough Furnace, for 2009 to 2013. Grey indicates missing values.



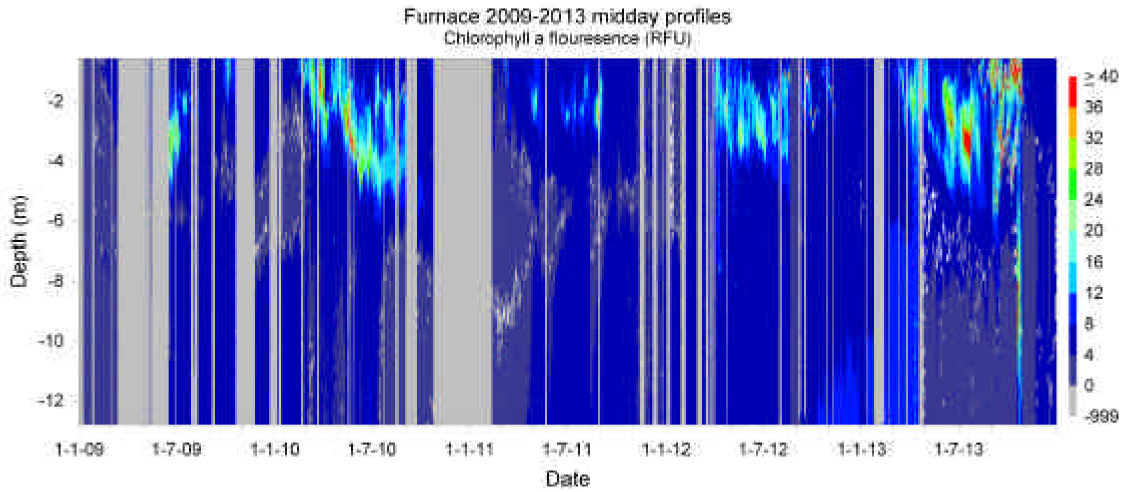


Figure 2-12: Long term Salinity (top) and Chlorophyll *a* (bottom) profiles from Lough Furnace, for 2009 to 2013. Grey indicates missing values.

3 Salmonid Rearing

3.1 Salmon Stocks 2012

3.1.1 Ranching

The total release in 2013 of microtagged smolts of ranched Burrishoole grilse origin into Lough Furnace was 33,912. Eight tag groups, including two groups treated with 'SLICE' for protection against lice infestation during early migration, were released on 7th May 2013. Mean weights ranged from 53 to 64 gms. One additional experimental group of 10,605 microtagged and H branded smolts, derived from Delphi two-seawinter parents, was also released on 7th May 2013 with an average weight of 59.6 gms. Smolt release was later than usual as water temperatures were slow to rise; only reaching 8^0 C by the end of April. At this time faint parr marks were still evident on salmon smolts and very few wild smolts had migrated through the downstream traps, reflecting the cold spring. A small group of surplus salmon smolts (1600) were exported to AZTI Foundation, Marine Research Division in Spain on April 27th 2013.

Tag code details are shown in Table 5.1.

3.2 Salmon Stocks 2013

Burrishoole ranch salmon and an experimental ranch group (see Salmon Stocks 2013 in Annual Report 2012 for details) were hatched in 2013. There was no commercial salmon production.

Growth and survival were satisfactory, although as a result of low water temperatures during the spring, the commencement of first feeding extended over an unusually long period (15th April to 24th May) and as fish were smaller, grading was later than usual (late August and September). In contrast, water temperatures of around 20^0C were recorded in the hatchery over a period of three weeks in July. In late September/early October, ranch salmon were mixed to produce core medium and large grade release groups.

Stocks remaining in December 2013 comprised 37,725 Burrishoole ranch and 7,132 experimental ranch stock (2nd generation derived from the progeny of Burrishoole 2SW ova from Delphi hatchery crossed with Burrishoole ranch grilse). In addition approximately 9,000 parr, surplus to requirements, were retained for sale in 2014.

3.3 Salmon Stocks 2014 (Grilse ova laid down in 2013/'14)

An estimated 60.6% of all returns, 59.5% of ranch grilse returns and 69.2% of 2SW returns were processed between May and August. Predator damage (from seals, cormorants, otters) was estimated to be 3.4% although in many cases wounds had healed.

Broodstock collection commenced from late August onwards and salmon were held in ponds until transfer to the broodstock holding pond on 20th September 2013 (82 males, 115 females). Broodstock collection continued into December and in total, 495 ranch adults (254 females, 241 males) were held during the stripping period.

Average water temperatures decreased from 8.5^0C to 6.3^0C during December and early January. Salmon were sorted on November 27th when 11 hens were found to be ripe. Branded, damaged and small salmon were culled prior to commencement of stripping (n=40). Stripping commenced on December 10th and extended over a six week period to January 14th 2014. In early December, many of the males were found to produce little or no milt, but milt production improved over time. On completion of stripping in January, the majority of remaining fish were culled but a subsample of the 48 unripe females remaining was retained to assess their potential for spawning at a later date. It is estimated that approximately 74% of females retained until 5th February were ripe at this stage and eggs were in good condition.

An estimated 513,000 green ova were produced by 174 females. The average fecundity value was 3,081 ova per grilse female (n=98) and 4,436 ova per 2SW female (n=15). A proportion of each family, from confirmed Burrishoole stock, was retained in the hatchery from each of the six stripping dates, totalling 64,600 eyed ova from 174 females (including 19 2SW, 2 wild) and 193 males (including 7 2SW, 1 wild). Ova quality and survival was good.

Broodstock condition was good throughout the holding period. Thirty ranch salmon broodstock were sampled in January 2014 and subsequently certified by the Marine Institute Fish Health Unit as disease free. During 2013, 45 salmon (with predator damage) were sampled to assess the incidence of *Anasakis* and post larvae of the cestode *Hepatoxylon trichiuri*, which were noted in 2011. *Anasakis* was observed in 82.2% of fish sampled and where present recorded as low (< 10 per fish) 73%, medium (10-50 per fish) 24.3% and high (>50 per fish) 2.7%. The presence of cestodes in the body cavity was noted in 40% of fish sampled.

3.4 Acoustic Tracking Programme

The acoustic tagging programme, which aims to examine behavioural differences and environmental preferences of wild and ranch adult salmon returns in Lough Feeagh, continued for another season. The last recovery (in the downstream traps) of salmon tagged in 2012 was in April 2013.

In July 2013, eight receivers were moored in Lough Feeagh, providing close to full coverage, and two receivers were placed in the Black river. Fifteen salmon were tagged with Vemco acoustic temperature/depth or depth tags between 25th June and 23rd September 2013. Data should provide novel insights into fish behaviour and inform important thematic research areas 'interactions of wild and cultured salmon' and 'climate change'. A scatter graph showing depth records for one wild female tagged on 3.08.12 and recovered on 19.03.13 is shown in Figure 3.1. Spawning is considered to have taken place between 2nd December 2012 and 21st December 2012.

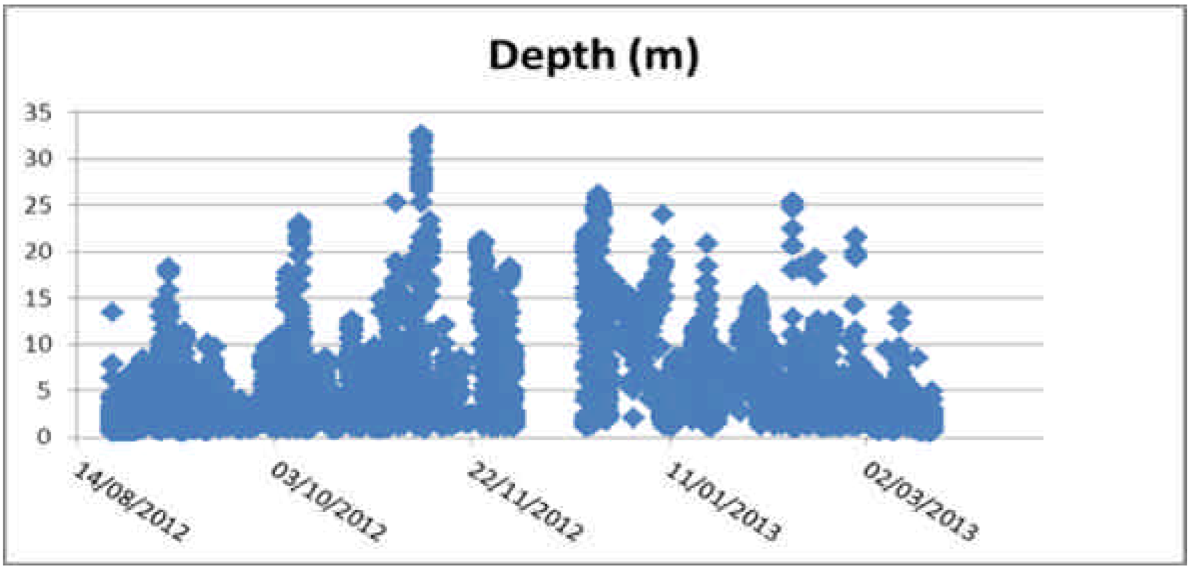


Figure 3-1: Scatter plot showing depth records for an acoustically tagged female in Lough Feeagh from August 2012 to March 2013.

4 Salmon Census Programme

The salmon census and stock assessment programme was continued in 2013 with a full upstream and downstream census of migrating wild salmon. The data provides a valuable index of salmon survivals and stock dynamics for the freshwater components of the stock.

4.1 Wild Salmon and Grilse

A total of 710 wild grilse, and 15 previously spawned grilse, were recorded moving upstream through the permanent traps during the season (Table 4.1). The general pattern of rainfall during June was of short periods of rainfall resulting in increased flow rates followed by longer periods without rainfall resulting in decreased flow rates. Although water levels were also low for much of July, heavy rainfall during the first and last week of the month raised water levels during the latter part of the month and the main upstream migration of wild salmon occurred in July when 44.5% of the migration was recorded.

A total of 607 grilse were recorded in the Salmon Leap trap and 103 grilse in the Mill Race trap.

The total number of spring fish recorded in the upstream traps was **23**.

One wild fish was retained in the rod catch of wild grilse on Lough Furnace and therefore the total wild grilse return to fresh water was **711** and **15** previously spawned grilse.

It was notable that considerable numbers of ranched grilse remained in the Mill Race pool below the fish fence through October into November and December before entering the traps. This has been observed previously but the numbers in 2013 appeared quite high.

Table 4-1: Monthly wild grilse totals for the Salmon Leap and Mill Race traps, 2013.

	Mill Race	Salmon Leap	Total	%
May	1	4	5	0.7
June	11	82	93	13.1
July	59	257	316	44.5
August	11	176	187	26.3
September	1	71	72	10.1
October	4	14	18	2.5
November	11	1	12	1.7
December	5	2	7	1.0
	103	607	710	100

Table 4-2: Monthly proportions (%) of the wild grilse run timing 2004-2013.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
May	0.0	0.4	0.5	0.3	0.0	0.0	0.0	0.2	0.1	0.7
June	36.0	23.9	1.4	7.7	9.1	4.6	0.9	16.8	29.8	13.2
July	41.0	13.2	40.1	56.3	17.9	78.7	75.8	43.4	57.1	45.0
August	9.8	39.1	31.9	17.5	62.6	15.5	15.5	29.8	10.1	26.6
September	10.9	14.8	22.8	14.9	7.3	0.9	6.7	8.4	2.4	10.3
October	1.0	5.5	2.5	1.0	2.9	0.2	1.0	0.6	0.4	2.6
November	0.7	3.0	0.5	1.3	0.2	0.2	0.1	0.8	0.0	1.6
December	0.5	0.2	0.3	0.8	0.0	0.0	0.0	0.0	0.0	0.0

Table 4-3: Wild salmon, grilse and previously spawned grilse (PSGs identified from floy tag recoveries) totals in the upstream traps, 1970-2013.

Year	Total Salmon	Total Grilse	Previously Spawned Grilse
1970-74	14	1145	
1975-79	36	703	
1980-84	35	449	
1985-89	22	492	
1990-94	16	421	
1995-99	12	509	
2000-'04	12	542	
2005-'09	22	642	
1995	15	582	
1996	18	409	
1997	6	538	
1998	4	516	
1999	16	502	
2000	6	568	
2001	6	368	
2002	2	648	
2003	18	544	
2004	28	580	
2005	9	532	
2006*	31	530	
2007*	12	1049	
2008	23	548	21
2009	37	549	10
2010	17	686	17
2011	50	523	7
2012	18	671	6
2013	23	710	15

* years where the grilse count was raised to account for loss in the traps.

4.2 Net marked fish in upstream traps

In 2007, the Irish Government introduced a cessation on drift netting in Irish coastal waters. The overall incidence of net marks recorded since the cessation in 2007 remains very low.

The overall incidence of net marks on wild and ranched fish was 2.8% and 1.8% respectively (Table 4.4). The highest monthly occurrence for both wild and ranched fish occurred in June, when 6.9% of wild fish and 5.9% of ranched fish were net marked.

Table 4-4: Percentage occurrence of net marks on wild and reared salmon, 2013.

	Wild %	n for wild/month	Reared %	n for reared/month
May	0.0	9	3.4	29
June	6.9	101	5.9	34
July	2.8	322	1.4	360
August	2.0	205	3.1	549
September	1.4	74	0.0	264
October	0.0	19	0.0	91
November	0.0	13	0.0	55
December	0.0	4	0.0	15
Total	2.80%	747	1.79%	1397

4.3 Wild Spawning Stock

The spawning stock (escapement) represents the number of fish available for spawning. It is calculated by subtracting rod caught fish and downstream-displaced fish as well as losses due to poaching, disease and predation, which have been estimated at 5% for wild fish and 10% for reared fish not displaced downstream.

In both 2006 & 2007, an additional number of fish, reared and wild, escaped upstream undetected (see previous reports). It is likely that the wild grilse count for those years were minimum figures and this was taken into account for all calculations based on the 2006 & 2007 spawning escapements.

4.3.1 Spawning escapement and stock

The total spawning stock in 2013 consisted of 691 wild fish and 11 reared fish (Table 4.5). The reared component was derived from 105 reared fish which were released upstream between June and September to provide an early component of reared returns for broodstock. A total of 92 reared fish were recaptured in the downstream traps prior to the spawning season of which 81 fish were retained as broodstock.

Table 4.6 gives the annual total spawning escapement, the wild escapement and the reared fish component. The spawning escapement of wild fish in 2007 was the highest observed over the last two decades. Particularly poor wild escapement was recorded in the 1990s and in 2001.

Table 4-5: Spawning stock of salmon and grilse, 2013.

	Wild grilse (1SW) & previously spawned grilse	Wild Salmon (2SW)	Ranched fish released upstream
Counted in trap	725	23	105
Rod Feeagh	0	0	0
Culled	7	0	11
Broodstock	0	0	81
Estimated morts.	35	1	1
Displacement	12	2	1
Spawning stock	**671**	**20**	**11**

* See Chapter 4.3.2.

Table 4-6: Spawning escapement, 1970-2013.

	Maximum spawning escapement	Wild fish component	Reared fish component
1970-74	1126	986	140
1975-79	725	683	42
1980-84	474	430	44
1985-89	662	428	232
1990-94	603	348	254
1995-99	519	428	95
2000-'04	516	494	21
2005-'09	624	587	38
1995	464	376	102
1996	594	355	239
1997	494	466	28
1998	498	456	42
1999	547	485	62
2000	567	527	40
2001	370	349	21
2002	570	562	8
2003	517	506	11
2004	554	528	26
2005	503	472	31
2006	552	520	32
2007	1038	958	80
2008	512	495	17
2009	517	489	28
2010	652	617	38
2011	548	512	36
2012	668	640	28
2013	702	691	11

4.3.2 Wild salmon broodstock stripped December 2013

No wild fish were stripped in 2013.

4.4 Survival from Ova to Grilse

The relevant brood year for the 2013 grilse was 2009 with ova hatched in 2009 and smolt migration in 2012 (Table 4.7).

As in previous years, it has been assumed for the purpose of estimating survival that ranched grilse spawned naturally. Specific data are not currently available on differential survival rates of wild and ranched stocks spawned in the wild. All relevant calculations are based on parameters set out in the Ann. Rep. No. 19, 1974.

Table 4-7: Survivals from ova to smolt and smolt to grilse.

Spawning escapement in 2009	517
No. of females	259 - 284
Ova deposition	1,034,000 – 1,170,100
No. of smolts in traps 2012	7717
No. of smolts released	7542
Survival ova to smolt*	0.75 – 0.66
No. returning grilse 2013	710
Survival smolt to grilse	9.4%
Survival to grilse per grilse female	***2.7 – 2.5***

* two estimates of the % females in the run using 50% and 55%

4.5 Ova to Smolt Survival

The survival of ova to smolt recorded in 2012 was 0.7 from a spawning escapement of 517 adults. For the five years prior to 2007 the average spawning stock was 539 and the average survival of ova to smolt was also 0.7.

There was a slight decrease in the percentage return of grilse increased from 10.5% to 9.4% from a released smolt migration of 7542. The survival to grilse per grilse female was 2.5 – 2.7 (Table 4.8).

Table 4-8: Percent survivals for ova to smolt and grilse per female grilse spawner; comparative data for 5-year averages from 1970-1989 and values for the individual brood years from 1990 onwards.

Brood year-class	% survival rates ova to smolt	survival rates to grilse per grilse female spawner
1970-74	0.48 - 0.62	1.4 - 1.7
1975-79	0.63 - 0.73	1.5 - 1.7
1980-84	0.61 - 0.69	1.7 - 1.9
1985-89	0.44 - 0.45	1.4 - 1.5
1990	0.47 - 0.54	1.8 - 2.0
1991	0.47 - 0.53	1.8 - 2.0
1992	0.48 - 0.54	1.3 - 1.5
1993	0.39 - 0.45	1.5 - 1.6
1994	0.36 - 0.41	1.3 - 1.4
1995	0.83 - 0.93	1.9 - 2.1
1996	0.53 - 0.61	1.8 - 1.9
1997	0.52 - 0.59	1.4 - 1.5
1998	0.58 - 0.60	2.4 - 2.6
1999	0.79 - 0.70	1.8 - 2.0
2000	0.56 - 0.64	1.9 - 2.1
2001	1.30 - 1.10	2.9 - 2.6
2002	0.56 - 0.64	1.7 - 1.9
2003	0.68 - 0.76	3.7 - 4.1
2004	0.53 - 0.60	1.8 - 2.0
2005	0.69 - 0.61	2.0 - 2.2
2006	0.75 - 0.67	2.4 - 2.6
2007	0.34 - 0.30	0.9 - 1.0
2008	0.65 – 0.57	2.4 - 2.6
2009	0.75 – 0.66	2.7 - 2.5

4.6 Wild Salmon Smolts

A total of 6355 smolts were recorded in the downstream traps in 2013 (Table 4.9). The smolt migration commenced on April 17th in the Salmon Leap which was a month later than the previous year. In 2013 water temperatures were lower than in recent years and the wind direction was predominately from the north. It is likely therefore that the low water temperature in 2013 resulted in delaying the migration despite adequate water flow. The peak of the migration was recorded in mid-May (Figure 4.1).

The total numbers of wild salmon smolts decreased from 7717 in 2012 to 6355 in 2013 (Table 4.10).

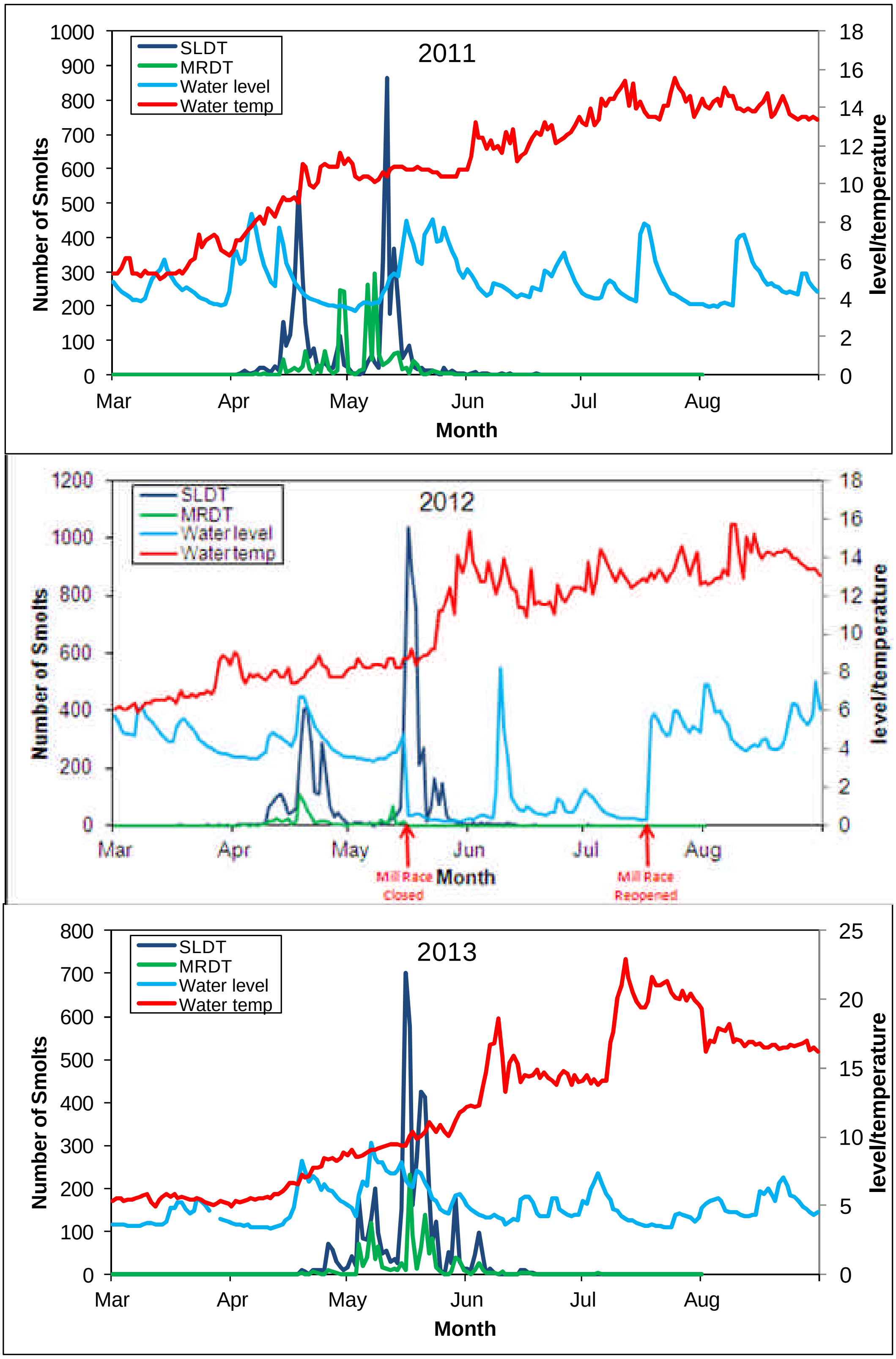


Figure 4-1: Timing of the 2011, 2012 and 2013 wild salmon smolt runs in the Salmon Leap and Mill Race traps with daily midnight water level (m x 10) and midnight temperature (^{0}C). Two smolts recorded in September 2011 were not shown. Note Mill Race closed with a dam at the upstream end from 16^{h} May to 17th July 2012.

Table 4-9 : Number of wild salmon smolts counted in 2013.

Month	Salmon Leap Down Trap	Mill Race Down Trap	Total
March	0	0	0
April	243	40	283
May	4439	1254	5693
June	271	94	365
July	5	4	9
August	4	1	5
September	1	1	2
TOTAL	4963	1394	6357

Table 4-10: Annual numbers of wild salmon smolts recorded in the downstream traps.

Year	1990-94	1995-99	2000-04	2005-09	2007	2008	2009	2010	2011	2012	2013
Smolts Counted	5618	7052	7490	7351	6685	6909	7980	7123	6629	7717	6357
Smolts Released		6967	7340	7138	6518	6691	7749	6979	6390	7542	5960

4.7 Wild Salmon Kelts

4.7.1 Census

Kelts migrate downstream after spawning. A total of 345 wild salmon kelts were recorded in the downstream traps between December 2012 and June 2013. The main downstream migration was recorded during March when 43.8% of the total migration was recorded (Table 4.11).

The overall survival of kelts from the spawning stock in 2013 was 53.9% which was similar to the previous year's survival of 54.7% (Table 4.12).

Table 4-11: Numbers of wild salmon kelts counted in 2013.

Month	SLDT	MRDT	Total
December '12	7	3	10
January '13	24	12	36
February	47	2	49
March	150	1	151
April	87	11	98
May	0	0	0
June	1	0	1
Total	316	29	345

4.7.2 Tagging of wild kelts

Following the cessation of drift netting during 2007 and the corresponding increase in the wild spawning stock at Burrishoole tagging of the wild kelts recommenced during 2008. A total of 333 floy tagged kelts were released from the downstream traps in 2013. During the summer of 2013 a total of 15 previously spawned grilse were recovered. The percentage recovery of PSGs for 2013 increased from 3.6% in 2012 to 4.5% in 2013 (Table 4.12).

Table 4-12: Comparison of annual salmon kelt runs.

Year	Kelt Quality Grade				
	A	B	C	D	E
1975-79	75	18	14	30	8.1
1980-84	82	18	6.7	48.7	9.7
1985-89	88	21	5.1	43.2	8.4
1990-94	92	31	4.8	61.4	6.6
1995	74	28	18.3	59.9	2.3
1996	88.1	27	10.1	53.1	4.0
1997	93.7	33.5	6.3	58.9	*
1998	94.3	30.8	5.7	67.6	*
1999	90.6	38.5	4.5	76	*
2000	92.5	44.5	5.5	62.1	*
2001	97	38.5	2.8	72.5	*
2002	91.3	40.9	7.8	49.6	*
2003	95.5	37	3.5	42.3	*
2004	89.9	36.3	9	53.2	*
2005	83.3	35.5	15.3	57.6	*
2006	82.2	36.1	16	54.4	*
2007	95	37.3	4.1	**	*
2008	93.2	26.9	6.8	**	5.6
2009	96.1	20.8	3.3	43.8	4.9
2010	98.1	13.5	1.3	34.2	10.1
2011	95.9	22.7	0.5	35.5	4.1
2012	96.7	20.8	2.8	54.7	3.6
2013	95.1	29.6	4.6	53.9	4.5

* no kelt tagging

** see section 4.7 (2007 report)

A = % healthy kelts in kelt run

B = % males in kelt run

C = % lightly marked

D = % survival from wild spawning escapement

E = % recapture of previously spawned grilse in first year

5 Reared Salmon Census Programme

A programme of rearing and releasing tagged salmon has been carried out in Burrishoole since the early 1960s. The stock was based originally on donor wild salmon from the Burrishoole system and the stock has been closed since using returning tagged fish as broodstock. Additional experimental groups are sometimes released and these are freeze branded and differentially tagged so as to avoid mixing these with the core ranched stock. The ranched stock facilitates data collection and comparison with the wild stock without putting undue stress or mortality on the wild stock – in this report the ranched stock are known as reared grilse and reared 2SW salmon.

5.1 Coastal Returns

Details of coastal returns of Burrishoole fish are available in the Marine Institute 'National Report for Ireland - The 2013 Salmon Season' report.

5.2 Return rate of reared and wild grilse

A total of 1338 microtags were recovered from reared fish returning to Burrishoole in 2013. Of the total recovery, 1296 were identified as Burrishoole core fish, of which 1217 were grilse and 79 were 2SW fish.

The average return rate of reared Burrishoole grilse to freshwater, as determined by microtags, was 2.9% which was lower than the return in 2012 of 4.89% but similar to that of 2011 of 2.9%.

For comparison, the percentage return of wild grilse also decreased in 2013 from 10.5% in 2012 to 9.4% in 2013.

5.3 Recapture of Reared 2SW Fish

The total number of microtagged 2SW reared fish recorded in Burrishoole during 2013 was 120 comprising of 5 core release groups (79 returns) and 3 experimental release group (41 returns).

5.4 Smolt Releases 2013

A total of 44,517 ranched smolts were released from Burrishoole during 2013. They consisted of nine individual microtag codes, eight of which were released as part of the on-going core ranching programme and one experimental group derived from Delphi 2-seawinter parents. All of the smolts were released into Lough Furnace on 7th June. For additional information, see section 3.1.1.

Table 5-1: Details of microtag codes and smolt release groups 2013.

Group ID	Tag Code	Mean Wt	Mean Length	No. Released	Date released
Core	64754	60.80	17.3	4362	07/05/2013
Core	64755	64.10	17.7	4,421	07/05/2013
Core	64756	59.95	17.2	4,433	07/05/2013
Core	64757	61.18	17.4	4,456	07/05/2013
Core	64758	56.50	17.0	4,502	07/05/2013
Core	64759	64.15	17.4	5,866	07/05/2013
Core	64760	61.22	17.2	2,703	07/05/2013
Core	64761	52.60	16.5	3,169	07/05/2013
Experimental	64775	59.60	17.0	10,605	07/05/2013

5.5 Reared kelts

In 2012 a total of 128 ranched fish were released upstream during the summer. By the end of December 2012 a total of 97 fish (76%) were recaptured in the downstream traps of which 85 were transferred to the broodstock ponds. In 2013, an additional 19 ranched grilse were recorded in the downstream traps. Therefore a total of 116 (91%) of the 128 fish released upstream in 2012 were accounted for in the downstream traps.

In 2013 a total of 105 ranched fish were floy tagged swabbed and released upstream. Between June and December, 93 (88.6%) of the fish released up were recaptured in the downstream traps the majority of which were retained as broodstock in the Smolt Unit.

In 2014 a further 10 ranched fish were recorded in the downstream traps. Therefore a total of 103 (98%) of the 105 fish released upstream in 2013 were accounted for in the downstream traps.

6 Wild Sea Trout Census Programme

6.1 Upstream Movements: Timing and Numbers.

A total of 70 wild silvered sea trout and a further 101 non-silvered trout migrated upstream through the traps in 2013. Of the silvered trout, 20 were adults and 50 (71.4%) were finnock. The numbers are compared with other years in Table 6.1. Of the total run of migratory (silvered and unsilvered) trout (171), 59.1% were unsilvered. For the purposes of this report, the unsilvered trout are not included with the sea trout. Table 6.1 shows that the numbers of sea trout have not recovered in the Burrishoole system and have shown a ten-fold drop since the 1970s.

Table 6-1: Annual runs of sea trout recorded in the traps.

Year	Mill Race	Salmon Leap	Total	Amended Total
1970-74	1365	762	2127	
1975-79	829	1775	2604	
1980-84	458	780	1238	1719 *
1985-89	386	590	978	
1990-94	134	72	206	
1995-99	86	91	177	
2000-04	32	64	97	
2005-09	21	44	65	
2000	33	78	111	
2001	31	58	89	
2002	26	89	115	
2003	45	33	78	
2004	26	64	90	
2005	5	10	15	
2006	16	22	38	
2007	35	59	94	
2008	4	36	40	
2009	45	93	138	
2010	10	62	72	
2011	15	53	68	
2012	19	120	139	
2013	20	50	70	

* See Table 34, Ann. Rep. XXX (1985); p. 43.

The timing of the sea trout run in 2013, and in previous years, expressed in monthly percentages, is given in Table 6.2. The highest proportion of sea trout, both finnock and adults, moved upstream in July and August. The unsilvered trout moved upstream from June to December with higher numbers in August and October.

Table 6-2: Timing of the Burrishoole (a) silvered sea trout run and (b) unsilvered trout run (in monthly percentages). (n = no. of trout).

(a) Silvered Trout

	1970-'79	1980-'84	1985-'89	1990-'94	1995-'99	2000-'04 (483)	2005-'09 (325)	2008 (40)	2009 (138)	2010 (72)	2011 (68)	2012 (139)	2013 (70)
May	-	0.2	0.5	0.1	3.1	2.0	1.3	0.0	0.0	0.0	13.2	1.4	1.4
June	13.1	24.6	9.4	8.4	8.6	16.7	9.0	0.0	2.2	0.0	0.0	11.5	4.3
July	54.4	44.9	62.2	55.0	42.4	37.5	32.5	10.0	88.4	85.9	16.2	60.4	30.0
Aug	15.8	10.3	18.4	16.5	19.3	26.4	38.1	82.5	6.5	8.5	35.3	18	44.3
Sept	7.6	14.8	3.7	8.5	9.8	5.7	13.6	5.0	0.7	5.6	22.1	5	5.7
Oct	6.4	3.5	4.1	7.9	12.2	10.2	4.7	2.5	2.2	0.0	7.4	2.9	12.9
Nov	2.4	1.5	1.5	2.9	4.3	1.5	0.7	0.0	0.0	0.0	5.9	0.7	1.4
Dec	0.3	0.2	0.2	0.7	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0

(b) ***Unsilvered Trout***

	2005 (86)	2006 (61)	2007 (94)	2008 (76)	2009 (91)	2010 (104)	2011 (87)	2012 (47)	2013 (101)
April	0	0	2.2	2.6	2.2	0.0	3.4	0	1.0
May	4.7	16.4	5.4	3.9	5.6	1.0	5.7	0	3.9
June	10.5	9.8	19.4	13.2	8.9	0.0	3.4	21.7	6.9
July	4.7	16.4	25.8	21.1	23.3	44.2	12.6	17.4	9.9
August	43	11.5	4.3	31.6	12.2	16.3	14.9	13.0	34.7
September	12.8	13.1	6.5	7.9	7.8	17.3	11.5	13.0	9.9
October	9.3	27.9	7.5	9.2	24.4	7.7	11.5	19.6	24.8
November	10.5	3.3	20.4	2.6	14.4	11.5	36.8	6.5	5.0
December	4.7	1.6	8.6	7.9	1.1	1.9	0.0	8.7	5.0

6.2 Spawning Escapement

With the continuation of the catch and release bye-law into the 2013 fishing season, no sea trout were reported killed by anglers on L. Feeagh in 2013. Using the upstream fish counts through the traps, the total maximum spawning escapement of migratory trout to the L. Feeagh catchment was 169, of which 94 were non-silvered sea trout.

Table 6-3: Annual spawning escapement of sea trout into freshwater, 1970-2013.

	1970-'79	1980-'84	1985-'89	1990-'94	1995-'99	2000-'04	2005-'09	2009	2010	2011	2012	2013
Max. Escap.	2090	1146	906	231	289	156	146	228	175	155	186	171
Revised	1622											

6.3 Downstream Movements, Sea Trout Smolts

The 2013 smolt run amounted to 485 smolts, of which 453 were released downstream (Table 6.4). Few smolts were recorded from January to March. The main migration occurred in April (39%) and May (55%) and was strongly regulated by both water level and water temperature (Fig. 6.1). The 2013 smolt count was low compared to the last few years (Table 6.5).

Table 6-4: Monthly numbers of Burrishoole sea trout smolts recorded through the traps.

Month	Salmon Leap	Mill Race	Total	%
January	4	0	4	0.8
February	0	1	1	0.2
March	4	0	4	0.8
April	163	27	190	39.2
May	232	33	265	54.6
June	14	3	17	3.5
July	4	0	4	0.8
Total	421	64	485	
Number Released Downstream			453	

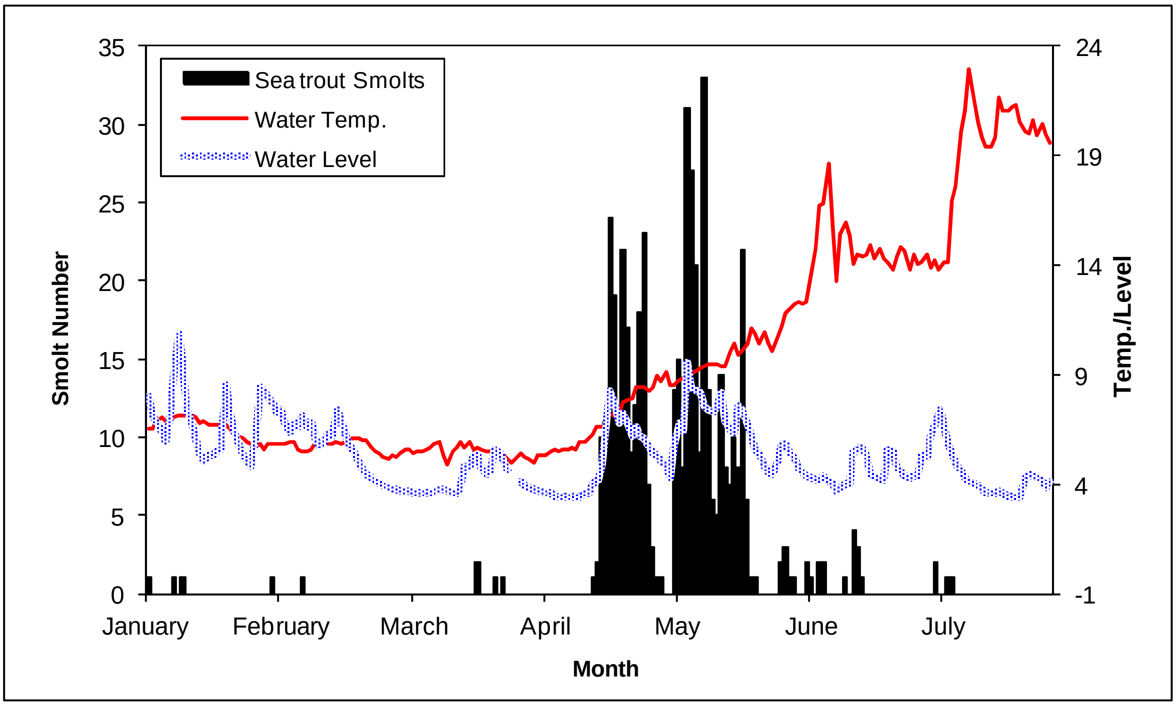


Figure 6-1: Timing of the 2013 wild sea trout smolt migration with daily midnight water level (m x 10) and midnight temperature (⁰C).

Table 6-5: Annual sea trout smolt numbers in Burrishoole for 1970 to 2013.

	1970-79	1980-84	1985-89	1990-94	1995-99	2000-04	2005-09	2009	2010	2011	2012	2013
Number of Smolt	4176	4038	4119	1531	1361	816	609	657	213	620	632	485

A total of 268 wild smolts were measured in 2013. Length measurements were taken to facilitate an estimated age breakdown of the smolt run. The estimated statistics for the 2013 smolts were a mean length of 19.7 cm and a range from 15.2 to 27.2 cm and the length frequency is presented in Figure 6.2 compared with that of 2011 and 2012. This gave an estimated age of 80.2% 2 year old and 19.8% 3 year olds.

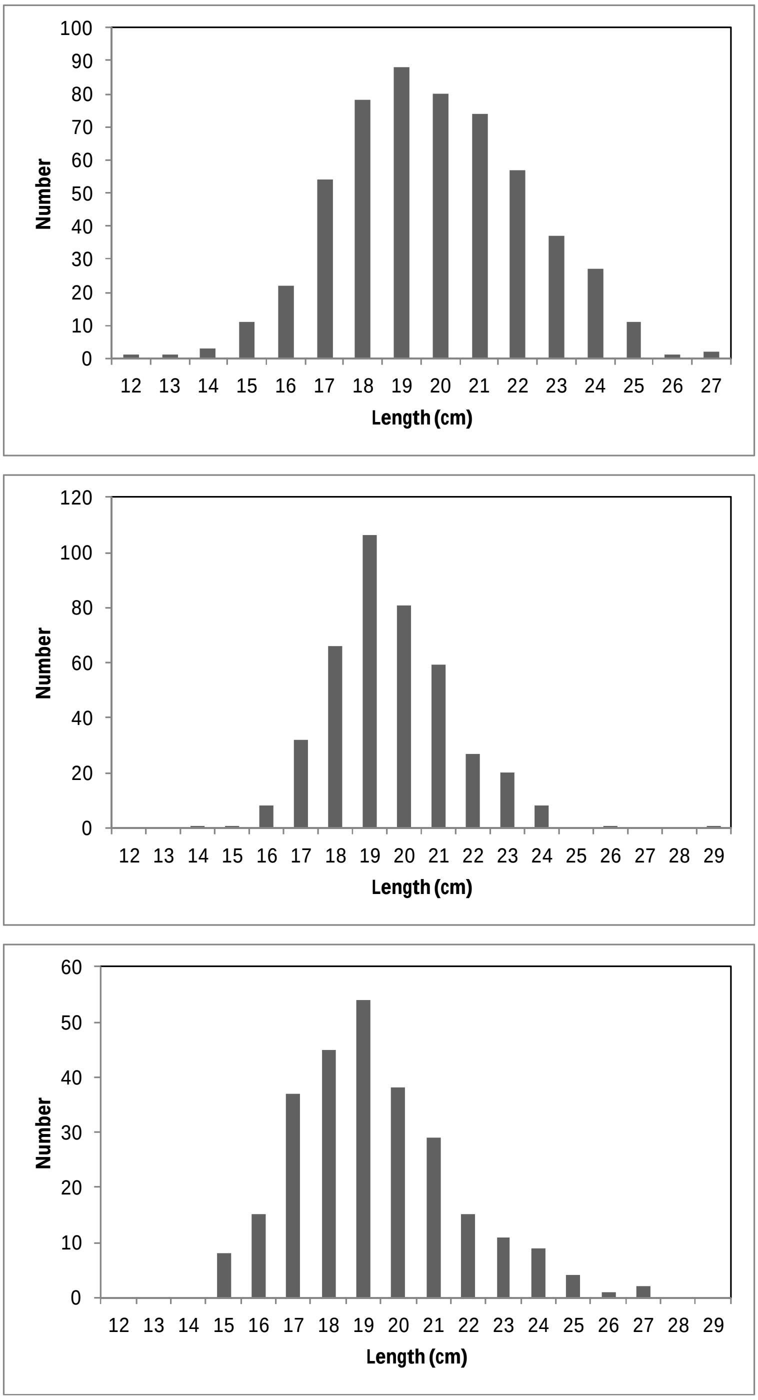


Figure 6-2: Length distributions for smolts in the Burrishoole system, top graph 2011 (n=547), middle graph 2012 (n=411) and bottom graph 2013 (n=268).

6.4 Autumn Migrating Smolts

These are juvenile trout (*Salmo trutta* L.) which generally move downstream through the traps from August to December. It is not clear whether these are true sea trout or part of the resident trout stock being displaced downstream. It is known through mark-recapture studies that a proportion of the 1+ autumn trout do return the following year as silvered finnock. These runs of trout would appear to becoming more prolonged with substantial numbers of un-silvered 0+ and 1+ trout continuing to migrate downstream in the early months of the year.

A total of 549 trout entered the downstream traps between July and December 2013 and up to May 2014 (Table 6.6). The percentage of 0+ trout that migrated over the period was 36.1% (Table 6.7).

Table 6-6: Numbers of migrating autumn juvenile trout in 2013, to the end of May 2014.

	0+		1+		Total	
Month	Salmon Leap	Mill Race	Salmon Leap	Mill Race	Salmon Leap	Mill Race
July	2	0	2	2	4	2
August	2	1	8	4	10	5
September	13	1	12	2	25	3
October	48	1	59	6	107	7
November	34	3	62	10	96	13
December	68	0	83	9	151	9
January '14	12	1	43	4	55	5
February '14	6	0	10	2	16	2
March '14	2	0	5	1	7	1
April '14	2	1	10	4	12	5
May '14	1	0	12	1	13	1
Total	190	8	306	45	496	53
Overall Total	198		351		549	

Table 6-7: Percentage of 0+ juvenile trout (<10cm) in the trapped autumn migrating trout.

Year	% 0+	Year	% 0+
1982	50.0	1998	33.5
1983	N/A	1999	42.0
1984	55.8	2000	47.8
1985	30.3	2001	56.3
1986	16.1	2002	32.8
1987	35.3	2003	48.9
1988	60.9	2004	35.5
1989	37.2	2005	37.3
1990	35.2	2006	51.2
1991	26.0	2007	27.9
1992	38.2	2008	28.2
1993	27.6	2009	25.0
1994	16.8	2010	34.9
1995	25.3	2011	37.6
1996	34.0	2012	47.3
1997	18.7	2013	36.1

6.5 Total Recruitment

The 0+ autumn trout will not be large enough to become sea trout smolts in the following spring. The remainder, predominantly 1+ year olds, could contribute to the overall recruitment of sea-run trout the following year. The exact proportion of 1+ autumn trout that become smolts in any given year is not known. It is only since 1982 that the proportion of 0+ trout amongst the autumn migration has been estimated. Thus the figures for total recruitment up to this time are over-estimated (Table 6.8).

From 1982, total recruitment was calculated by adding the number of sea trout smolts produced in any one year to the total of 1+ autumn trout the previous year (Table 6.9). The assumption is made that all the 1+ autumn trout will become sea trout smolts and that no 0+ trout from the two years previous will be recruited as smolts. The fate of 1+ unsilvered juveniles migrating downstream in January to May is unknown but it would seem unlikely that these will contribute to the 2 year old spring smolt migration.

Table 6-8: Estimates of total migrant trout recruitment up to 1981.

Year	Smolt Total	Autumn trout (preceding year)	Total Recruitment
1970-74	4450	2870	6746
1975-79	4314	3186	7489
1980	2337	2351	4688
1981	6710	2631	9341

Table 6-9: Estimates of total migrant trout recruitment from 1982 to date.

Year	Smolt Total	1+ Autumn trout (preceding year)	Total Recruitment
1982-84	3714	1203	4917
1985-89	3706	1063	4778
1990-94	1788	399	2187
1995-99	1361	498	1860
2000	769	358	1127
2001	530	218	748
2002	1272	910	2100
2003	787	976	1763
2004	723	426	1149
2005	777	590	1367
2006	628	251	879
2007	593	377	970
2008	393	534	927
2009	657	495	1152
2010	213	267	480
2011	620	501	1121
2012	632	493	1125
2013	485	536	1021

6.6 Marine Survival

An estimate of sea trout survival to first return to freshwater can be more accurately calculated by the use of trap census data rather than rod catch returns of tagged or marked fish. Small numbers of stray fish are captured in other systems and it is not known whether these fish would have returned to their natal systems to spawn. Finnock are known to wander between river systems and are therefore not as reliable for assessing survival.

The pattern of marine survival found is similar whether the number of smolts is used or the combined total recruitment of smolts and autumn 1+ trout. The percentage of smolts that return as finnock (0+ sea age) in the same year historically ranged from 11.4% to 32.4% (Fig. 6.3). In 1988 it fell below the previous recorded minimum to 8.5% and in 1989 to a minimum of 1.5%. There has been a saw-tooth pattern of finnock return in the 1990's rising to 16.7% in 1999, 18.1% in 2009 and 17.5% in 2010 – the highest return rates since 1986. These increases were not, however, always sustained in subsequent years and there was a collapse in 2005 down to 1.5%. This was associated with the heaviest infestations of sea lice observed in the Burrishoole area since 1992. The return of smolt as finnock in 2011 was 8.1%, 16.9% in 2012 and 11.0% in 2013.

The total survival of smolts to their first return to freshwater as finnock in the same year and one year old sea trout in the following year (always an over-estimate as a proportion of finnock re-entering freshwater in year 1 return as sea trout in year 2 (Mills *et al*, 1990)) also showed a drop in survival from 1987 to 1989 (Fig. 6.4).

Historically, the total survival to first return ranged from 19% to 66%. This collapsed to 1.8% in 1989 but rose to 12.1% in 1990. However, little further improvement was recorded in 1991 (12.8%). Marine survival fell to the second lowest level in 1992 but returned to 13.1% for the 1993 year class of smolts. There was a further increase in 1994 to 18.2% but a drop in 1995 to 8.1%. There were marginal improvements again in 1996 (12.8%) and 1997 (13.3%), a drop to 8.3% in the 1998 year class and a marked improvement in the 1999 year class where marine survival was 20%, the highest recorded in 12 years and back within the pre-collapse historical range. Total survival increased for the 2009 cohort to the highest recorded level since 1988 of 23% and to 25.1% for the 2010 cohort. For the 2011 cohort of smolts, it was 13.5% and for the 2012 cohort it was 20.9%.

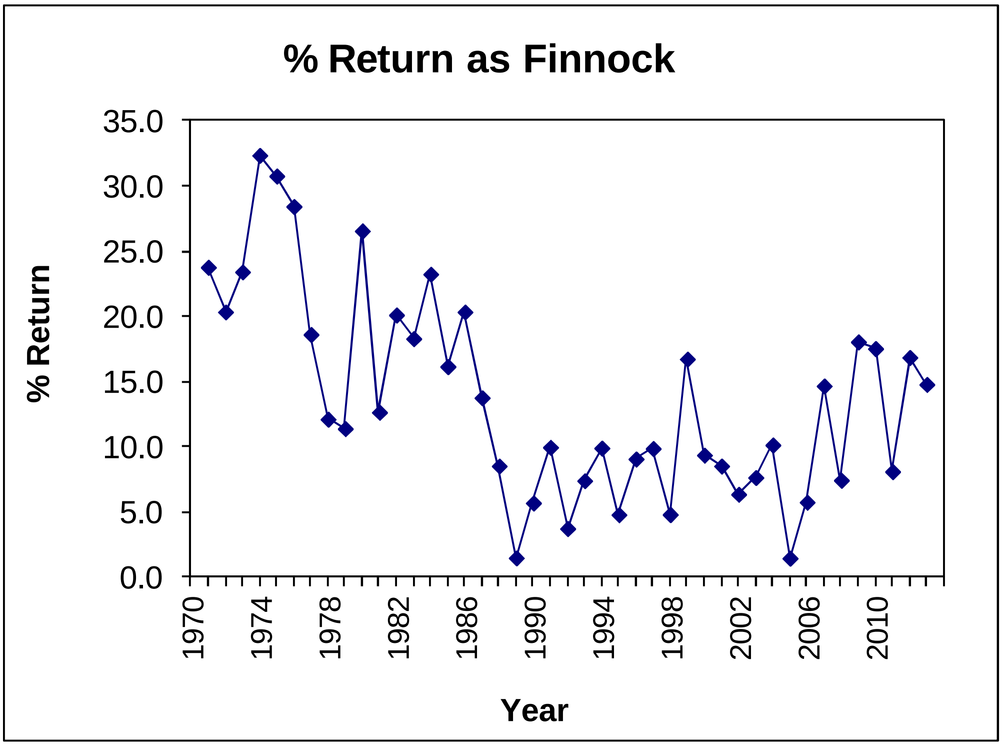


Figure 6-3: Annual percentage return of smolts returning as finnock to the Burrishoole system.

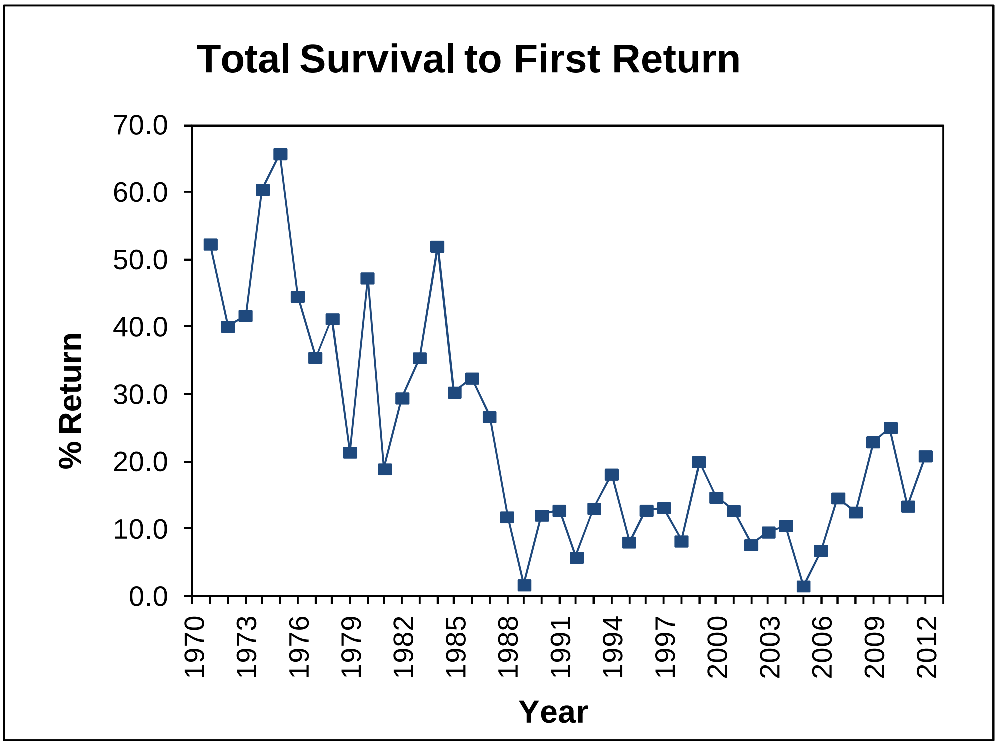


Figure 6-4: Annual marine survival of smolts to first return (as finnock and 1+ sea trout) to the Burrishoole system.

6.7 Sea Trout Kelts

Table 6.10 gives the numbers of sea trout and brown trout kelts, both spawned and immature, counted downstream in the winter of 2012 and spring of 2013.

The freshwater survival of kelts is given in Table 6.11. In some years, the number of kelts migrating downstream has exceeded the number of upstream migrants. This occurred in the early '80s when the screen allowed finnock to escape. This was rectified. More recently, the difficulty in separating small finnock and large smolts has led once again to a discrepancy as shown in Table 6.11. In addition to the size overlap, trout counted upstream as unsilvered migrants may be counted downstream as silvered kelts, and immature autumn downstream migrants may be misidentified as brown trout kelts, both causing additional difficulties in making survival estimates.

Since 1987, only one survival rate has been given for all sizes as it has been shown that a proportion (at least 33%) of the sea trout population may over-winter in freshwater. These fish do not spawn and continue to grow. There is also the additional complication of larger smolts and reduced sea growth mentioned above. Thus the comparisons of the proportion of fish in different year classes between the upstream migrants of one year and the downstream migrants of the next are invalidated.

In 2012/13, sea trout kelt survival increased to 117.5% and for finnock (small sea trout) it was 106%.

Table 6-10: Timing and numbers of sea trout kelts for the 2012/2013 season.

Month	Large ST	Small ST	BT	Total ST	Total Trout
October '12	0	1	7	1	8
November	7	5	22	12	34
December	3	10	17	13	30
January '13	5	10	11	15	26
February	0	4	9	4	13
March	3	1	0	4	4
April	13	21	3	34	37
May	14	24	1	38	39
June	0	0	2	0	2
Total	45	76	72	121	193

Table 6-11: Annual survival rate to sea trout kelt, as % of the upstream escapement of the previous year.

Year	Larger (> 30.0 cm)	Small (< 30.0 cm)	Year	Larger (> 30.0 cm)	Small (< 30.0 cm)
1976	79	66	1995	96.20%	“ *
1977	63	45	1996	127.70%	" *
1978	50	66	1997	97.00%	" *
1979	33	107*	1998	140.10%	" *
1980	50	82	1999	110.40%	" *
1981	44	345*	2000	70.10%	"
1982	53	203*	2001	82.00%	" *
1983	63	177*	2002	129.60%	" *
1984	74	210*	2003	66.10%	"
1985	70	98	2004	120.50%	"*
1986	66	72	2005	142.20%	"*
1987	58.7%	(combined)	2006	110.50%	"
1988	65.50%	"	2007	228.90%	"**
1989	68.70%	"	2008	98.90%	"**
1990	79.00%	" *	2009	107.50%	"*
1991	98.70%	" *	2010	59.40%	"
1992	89.50%	" *	2011	88.90%	"*
1993	96.70%	" *	2012	117.65%	"*
1994	104.60%	" *	2013	161.33%	"*

* Years when the number of finnock kelts counted downstream exceeded the number counted upstream during the previous season.

7 Silver Eel Census Programme

7.1 Numbers

Silver eel trapping was continued in 2013. The main run (68%) occurred in October (Table 7.1). Figure 7.1 shows the daily counts of silver eels.

The total run amounted to 3633 eels. As in other years, the highest proportion of the total catch (74.5%) was made in the Salmon Leap trap.

The Mill Race trap operated normally for the whole season following the refurbishment in 2012.

Table 7-1: Timing and numbers of the 2013 silver eel run.

	Salmon Leap	Mill Race	Total	%
June	1	1	2	0.1
July	18	7	25	0.7
August	119	61	180	5.0
September	219	99	318	8.8
October	1771	681	2452	67.6
November	308	35	343	9.5
December	218	29	247	6.8
Jan. 2013	47	6	53	1.5
February	5	0	5	0.1
March	2	0	2	0.1
April	1	0	1	0.0
May	4	1	5	0.1
Total	2713	920	3633	

7.2 Size

Sampling of individual eels (n = 1332) gave an average length of 42.7cm (range: 26.8 – 99.4cm) and an average weight of 157.3g (Table 7.2). The length frequency distribution is presented in Figure 7.2 along with those for 2011 and 2012 for comparison.

Counts of silver eel between the years 1971 (when records began) and 1982 averaged 4,400, fell to 2,200 between 1983 and 1989 and increased again to above 3,000 in the '90s (Fig. 7.3). There was an above average count in 1995, possibly contributed to by the exceptionally warm summer. The count in 2001 of 3875 eel was the second highest recorded since 1982. The average weight of the eels in the samples has been steadily increasing from 95 g in the early 1970s to 216 g in both the 1990s and the 2000s (Fig. 7.3). The annual count and average weight in 2010 and 2011 were both below the mean for the last decade.

In 2012, the majority of the eel run was sampled (n=3317; 99.5%). The run increased from 1969 in 2011 to 3335 in 2012 and the average weight decreased from 180 to 163.5g. The sex ratio changed from 24% to 45% over the past five years. Male eels have remained the same length over the past 15 years (36cm) whereas the females have changed from 53cm (1997-2005) to 50cm (2008-2012) and they were 49.2cm in 2012.

In 2013, the migration was 3633 eels and 1332 were sampled. The mean weight was 157.3g and the proportion of male eels was similar to that in 2012 at 45.7%.

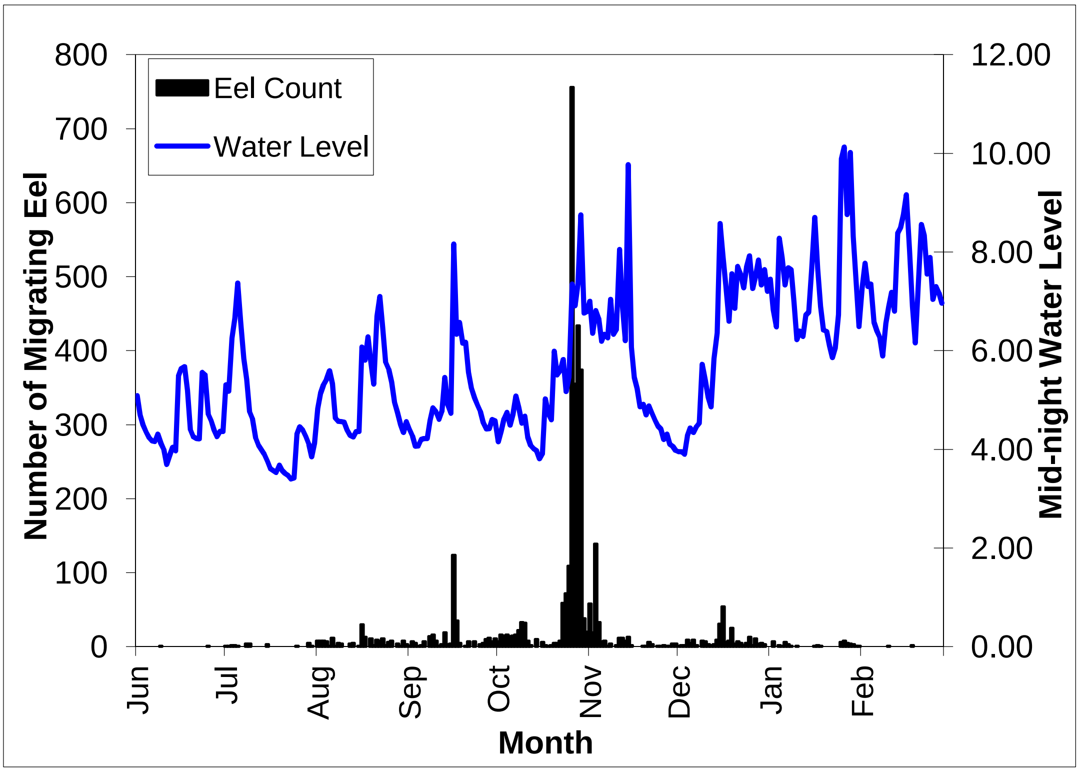


Figure 7-1: Daily counts of downstream migrating silver eel and mid-night water levels (m).

Table 7-2: Comparative data for the silver eel runs since 1971.

Years	Number Sampled	Mean. Weight (gm)
1971 - '75	4465	84
1976 - '80	4023	115
1981 - '85	2678	171
1986 - '90	11658	196
1991 - '95	3441	227
1996 - '00	3958	212
2001	850	238
2002	732	207
2003	650	177
2004	382	216
2005	587	237
2006	493	225
2007	571	201
2008	796	234
2009	220	209
2010	982	192
2011	1835	180
2012	3317	163
2013	1304	157

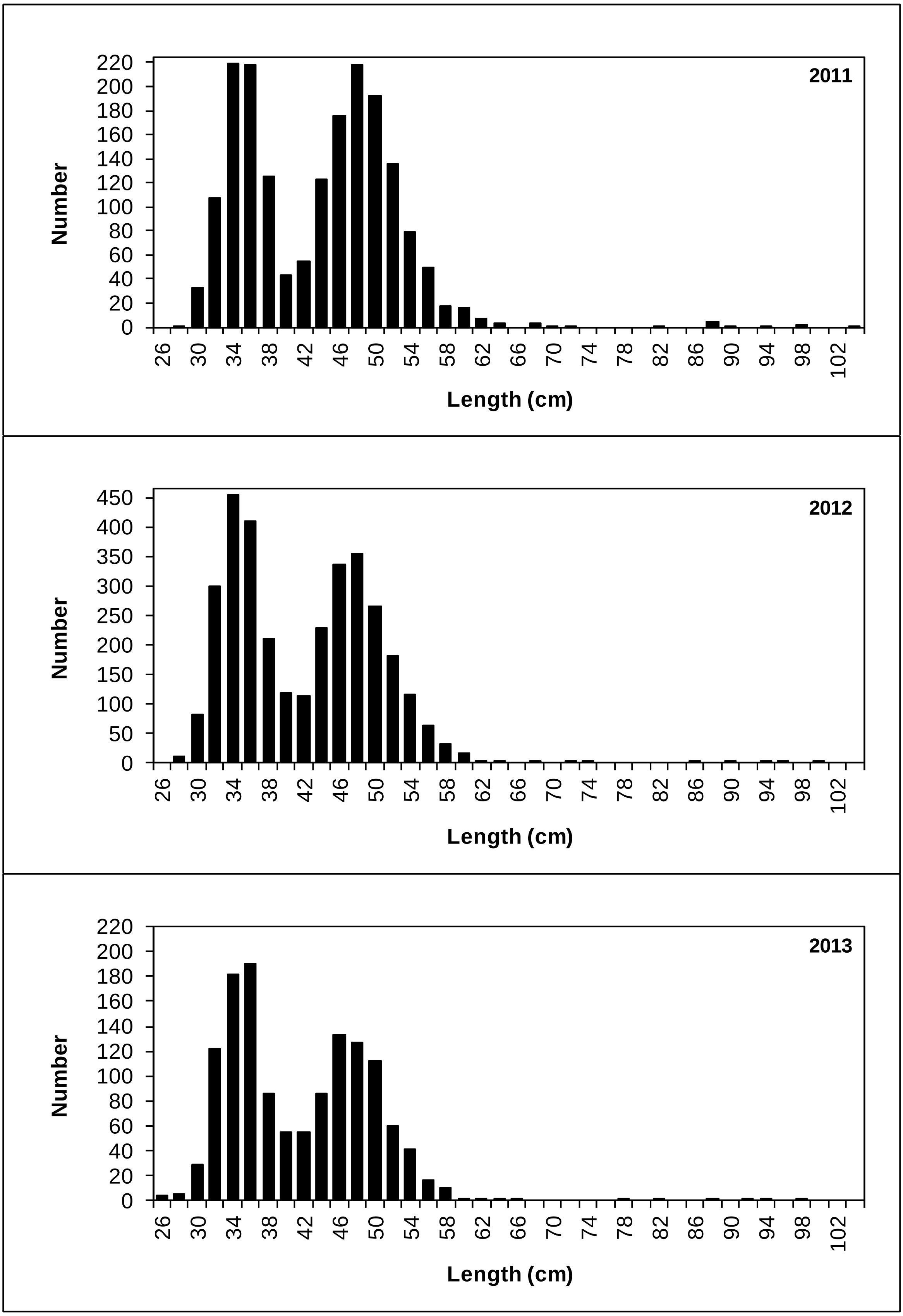


Figure 7-2: Length frequency of sub-samples of silver eels trapped in the downstream traps, 2011 (n = 1835), 2012 (n=3317) and 2013 (n=1329). Note change of y-axis scale in 2012.

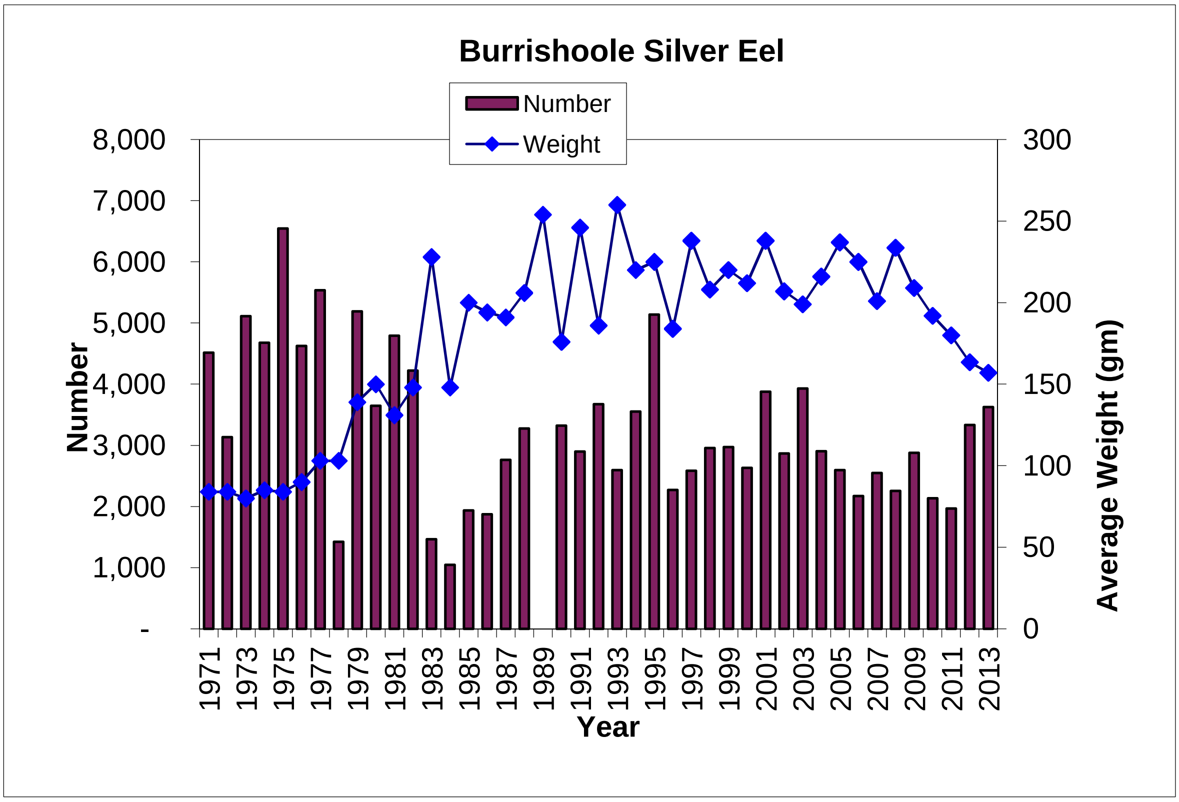


Figure 7-3: Annual number and mean weight of silver eels trapped in the downstream traps.

8 Fishery Report - Catch Data

The Burrishoole Fishery is a valuable part of the overall stock census programme and is run as an integral part of the monitoring programme. As part of the conservation of the Burrishoole wild stock, changes to the active season and to the parts of the catchment being fished have caused differences, or gaps, in the data being collected. Lough Feeagh, which had been closed to angling since 1997 for conservation reasons was opened to angling for the month of September in 2008, on a catch and release basis for wild fish. In 2009 - 2013 Lough Feeagh was open for angling on a catch and release basis from August to the end of September.

During 2013 Lough Furnace was open to angling from 17th of June to the 30th September and Lough Feeagh from July 29th to September 30th. The fishery was operated on a 5 day week from Wednesday to Sunday inclusive and on a catch and release basis for wild fish.

8.1 Numbers and Average weight of Rod Catch

The Lough Furnace rod catch in 2013 consisted of 19 wild fish and 70 reared fish and the Lough Feeagh catch of 16 wild fish and 1 reared fish. All wild caught fish were returned alive.

The average weight of reared fish was 1.7kg (n = 69) and the heaviest fish was 3.1kg. No lengths or weights are available for wild fish due to catch & release being in place.

A total of 30 sea trout were caught on Lough Furnace and 10 sea trout on Lough Feeagh. Regulations remained in place whereby all rod caught sea trout were returned alive.

In addition to the sea trout caught on Lough Feeagh, a total of 474 brown trout were also caught on the lough.

8.2 Timing of Catch and Rod Effort

Overall angling conditions were not ideal during 2013. However unlike last year when very wet conditions during the fishing season resulted in favourable conditions for fish to migrate upstream into Lough Feeagh rainfall amounts in 2013 were much lower. Short periods of heavy rainfall at the beginning and end of July and early August resulted in more favourable angling conditions. The highest catch of both wild and reared salmon on Lough Furnace was recorded in August which was also the period of greatest angling effort.

Overall there was an increase in rod effort on Lough Furnace from 809 hours in 2012 to 1073 hours in 2013

Lough Feeagh opened for angling on July 29th and was fished primarily by two anglers fishing for five full days during the first week and half days from the remainder of the season. The rod effort in 2013 of 227 hours was similar to that of the previous year of 225 hours. The catch of both wild and reared salmon was lower than the previous year with the wild catch decreasing from 28 to 16 and the reared from 3 to 1.

Table 8-1: Wild and reared salmon rod catch and rod effort (hours) for the 2013 season for L. Furnace and L. Feeagh.

Furnace

	Salmon Catch		Effort in hours
	Wild	Reared	
May	0	0	0
June	5	8	154
July	4	21	376
August	8	35	419
September	2	6	124
Total	19	70	1073

Feeagh

	Salmon Catch		Effort in hours
	Wild	Reared	
May	0	0	0
June	0	0	0
July	1	0	16
August	8	0	182
September	7	1	29
Total	16	1	227

8.3 Exploitation Rates of Rod Fishery

Rod exploitation rates for Lough Furnace and Lough Feeagh from 2003 to 2011 are shown in Table 8.2. From 1997 onwards Lough Feeagh was closed to angling. Exploitation rates are only available for Lough Furnace since 1997. The cessation of angling on Lough Feeagh was due to the continuing low stock level of wild fish. Following the cessation of drift netting in 2007 and the increased return of wild fish it was decided to re-open Lough Feeagh in 2008 to angling for the month of September only on a catch and release basis for both wild and ranched fish. Since 2008, and in future years, the running of a fishery on L. Feeagh was reviewed each year and was dependent on sufficient wild stock being present.

No sea trout angling has been permitted on L. Feeagh since 1997 and any fish captured are returned alive.

Anglers fishing on Lough Furnace were requested to return wild fish alive to the water. Injured or damaged wild fish were permitted to be retained; therefore, the rod catch on Lough Furnace consists of a total catch which includes released fish and a retained catch which are fish that have been killed.

Rod exploitation rates for Lough Furnace and Lough Feeagh from 2004 to 2013 are shown in Table 8.2.

Table 8-2: Rod fishing exploitation rates (2002-2013).

	2005	2006	2007	2008	2009	2010	2011	2012	2013
WILD SALMON									
Lough Feeagh									
"Available" fish by end of fishing season	*	*	*	531	585	691	516	683	694
Total rod catch				18	5	8	13	28	16
Rod catch retained				0	0	0	0	0	0
Angling success %[1]				3	0.85	1.15	2.5	4.10	2.31
Exploitation rate %[2]				0	0	0	0	0	0
WILD SALMON	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Loughs Feeagh & Furnace									
Total stock of wild fish	542	566	1063	572	587	703	571	686	734
+ 10% addition for									
L. Furnace population	596	623	1169	629	646	773	628	755	807
Total catch of wild fish	27	48	26	52	12	26	36	50	35
Rod catch retained	1	5	2	1	1	0	0	0	1
Max. angling success %	5.0	8.5	2.4	9.1	2	3.7	6.3	7.3	4.8
Min. exploitation rate	0.2	0.9	0.2	0.2	0.2	0	0	0	0.1
Max. exploitation rate	0.2	0.8	0.2	0.2	0.2	0	0	0	0.1
REARED SALMON	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Lough Feeagh									
"Available" fish by end of fishing season	*	*	*	98	115	130	125	128	105
Total rod catch				1	1	1	1	3	1
Rod catch retained				0	0	0	0	0	0
Angling success %[1]				1.0	0.9	0.8	0.8	1.5	1.0
Exploitation rate %[2]				0.0	0	0	0	0	0
Loughs Feeagh & Furnace									
Total stock	952	954	2624	1865	456	940	1293	2392	1301
Total rod catch	28	66	169	116	7	79	86	78	71
Exploitation rate %	2.9	6.9	6.4	6.2	1.7	8.4	6.7	3.3	5.5
WILD SEA TROUT	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Lough Feeagh									
"Available" fish by end of fishing season	*	*	*	39	135	71	58	129	53
Rod catch				3	12	1	1	5	12
Exploitation rate %				0	0	0	0	0	0

8.4 Angling Success

Table 8.3 presents the Catch per unit effort (CPUE) which is the number of fish caught per rod day, and the Effort per unit catch (EUPC) which is the number of rod days it takes to catch a fish.

Table 8-3: Catch per unit effort (CPUE) and effort per unit catch (EPUC) for the Burrishoole Fishery based on a eight hour fishing day. Salmon includes both wild and reared.

	Lough Furnace				Lough Feeagh			
	Salmon		Sea Trout		Salmon		Sea Trout	
Year	CPUE	EPUC	CPUE	EPUC	CPUE	EPUC	CPUE	EPUC
'80-'84	0.13	9.92	0.85	1.35	0.23	4.47	0.63	2.10
'85-'89	0.24	4.89	0.46	5.09	0.24	4.57	0.29	70.30
'90-'95	0.20	6.10	0.17	16.80	0.20	5.40	0.10	14.00
'96	0.22	4.40	0.10	10.50	0.83	1.20	0.30	2.90
'97	0.17	6.00	0.10	9.60	*	*	*	*
'98	0.44	2.30	0.08	13.20	*	*	*	*
'99	0.09	10.80	0.05	20.80	*	*	*	*
'00	0.30	3.31	0.06	16.50	*	*	*	*
‘01	0.15	6.70	0.12	8.40	*	*	*	*
’02	0.12	8.30	0.07	15.30	*	*	*	*
’03	0.13	7.60	0.06	17.70	*	*	*	*
’04	0.22	4.60	0.16	6.30	*	*	*	*
’05	0.26	3.80	0.08	13.00	*	*	*	*
’06	0.44	2.30	0.04	23.50	*	*	*	*
’07	0.49	2.10	0.14	6.90	*	*	*	*
’08	0.35	2.89	0.05	21.60	0.46	2.18	0.07	13.80
’09	0.18	5.66	0.24	4.09	0.21	4.75	0.42	2.38
’10	0.60	1.66	0.14	7.27	0.82	1.22	0.09	11.00
'11	0.68	1.47	0.35	2.8	1.06	0.95	0.08	13.1
’12	0.96	1.04	0.1	10.1	1.1	0.91	0.18	56.62
'13	0.66	1.51	0.22	4.5	0.6	1.7	0.42	2.4

9 Collaborative Research Programmes

9.1 Beaufort Fish Population Genetics

MI Newport is committed to supporting a number of agreed projects that are facilitated and undertaken as part of the Beaufort Fish Population Genetics Programme. The Marine Research Award in Fish Population Genetics was granted by the former Department of Communications, Marine and Natural Resources to University College Cork and Queens University Belfast in June 2007.

The Newport facility has collaborated with the Beaufort genetics group on a number of key programmes:

(i) Evolutionary genomics: pedigree reconstruction in a 40 year salmon monitoring project to reveal the association within families between qualitative and quantitative variation, and its contribution to population fitness. Collaborating Institutes: University of Turku, Finland; Beaufort Marine Research Award in Fish Population Genetics; Marine Institute.

The Burrishoole system offers a unique opportunity for reconstructing multigenerational pedigrees because of the intensive sampling of the population over four decades and the associated ecological and environmental information available. Pedigree based analysis is a powerful method for separating genetic effects from environmental effects on the phenotype, as demonstrated by their common use in domestic animal breeding programmes. However, pedigrees in the wild have rarely been constructed in any vertebrate especially fish, because of the logistical and technical difficulties in identifying and following the performance of individual families. Due to recent technological and analytical advances, combined with the sequencing of the salmon genome, salmon now provide a unique opportunity for study because of their fecundity, large family size and extensive information on ecology of the species.

To date, scale samples have been provided from selected year classes of adult salmon (1977 – 2009) and swab samples have been collected from contemporary populations since 2011. Genetic and statistical analysis for the salmon pedigree programme is being carried out by the University of Turku, funded by the Finnish Academy of Sciences.

(ii) Local adaptation in Atlantic salmon (*Salmo salar*)

A series of work programmes are in progress, which aim to determine the scale of biologically important local adaptation at small geographical scales, in Atlantic salmon and brown trout, using a common garden experimental approach:

- To assess the importance of local adaptation at small geographical scales by comparing the relative fitness of the progeny of Burrishoole and Owenmore Atlantic salmon parents and their reciprocal hybrids in a common natural environment (Partners: MI Newport , Beaufort Ph.D. studentship UCC).

- The establishment of a common garden experiment in the Srahrevagh (Burrishoole) and Tawnyard (Erriff) experimental rivers for the study of local adaptation in Atlantic salmon (Partners: MI Newport, WRFB, Beaufort Group).

- To assess the importance of local adaptation at small geographical scales by comparing the relative fitness of the progeny of Burrishoole and Bunavela brown trout parents and their reciprocal hybrids in a common natural environment (Partners: MI Newport, Beaufort Group).

Trapping facilities on the Rough river were serviced on a daily basis from March 2009 and fish in the downstream traps were recorded and sampled according to protocol. Salmon smolts (2+) collected in spring 2011 and 2012 marked the end of the freshwater component for these studies and genotyping and assignment of fish samples is ongoing. Traps were re-opened in November 2012 for collection of wild salmon moving upstream and sampling of downstream migrants (predominantly trout) from November 2012 to January 2013. The Institute has facilitated a number of other projects in collaboration with the Beaufort Group by way of providing samples to support a number of research projects in Queens University Belfast and University College Cork.

Beaufort Trout MicroPlex: a high throughput multiplex platform comprising 38 informative microsatellite loci for use in brown trout and sea trout (*Salmo trutta* L.) population genetics studies

Using genetic stock identification to elucidate the biology and ecology of the brown trout/sea trout (*Salmo trutta*) population complex in the Burrishoole system, west of Ireland

Patterns of variation in adaptive traits and neutral markers across a three-spine stickleback (*Gasterosteus aculeatus*) freshwater-anadromous hybrid zone

Local adaptation in Atlantic salmon (*Salmo salar*): seeking empirical evidence within a common garden experimental framework (the Owenmore experiment)

Local adaptation in Atlantic salmon (*Salmo salar*): seeking evidence within a reciprocal transfer common garden experimental framework (the Erriff experiment)

Local adaptation in brown trout (*Salmo trutta*): seeking evidence within a common garden experimental framework (the Bunaveela experiment)

Evolutionary genomics: pedigree reconstruction in a 40 year salmon monitoring project to reveal the association within families between qualitative and quantitative variation, and its contribution to population fitness

Clock gene variation: insight into qualitative variation underlying run timing and sea age in Atlantic salmon (*Salmo salar*)

Assessing the V-notching as viable tool for the conservation and long term sustainability of European lobster (*Homarus gammarus*) stocks

Parallel phenotypic response of Atlantic salmon *Salmo salar* and brown trout *Salmo trutta* to different river environments

9.2 Lakes Studies

Estimating carbon pools and processing in a humic Irish lake.

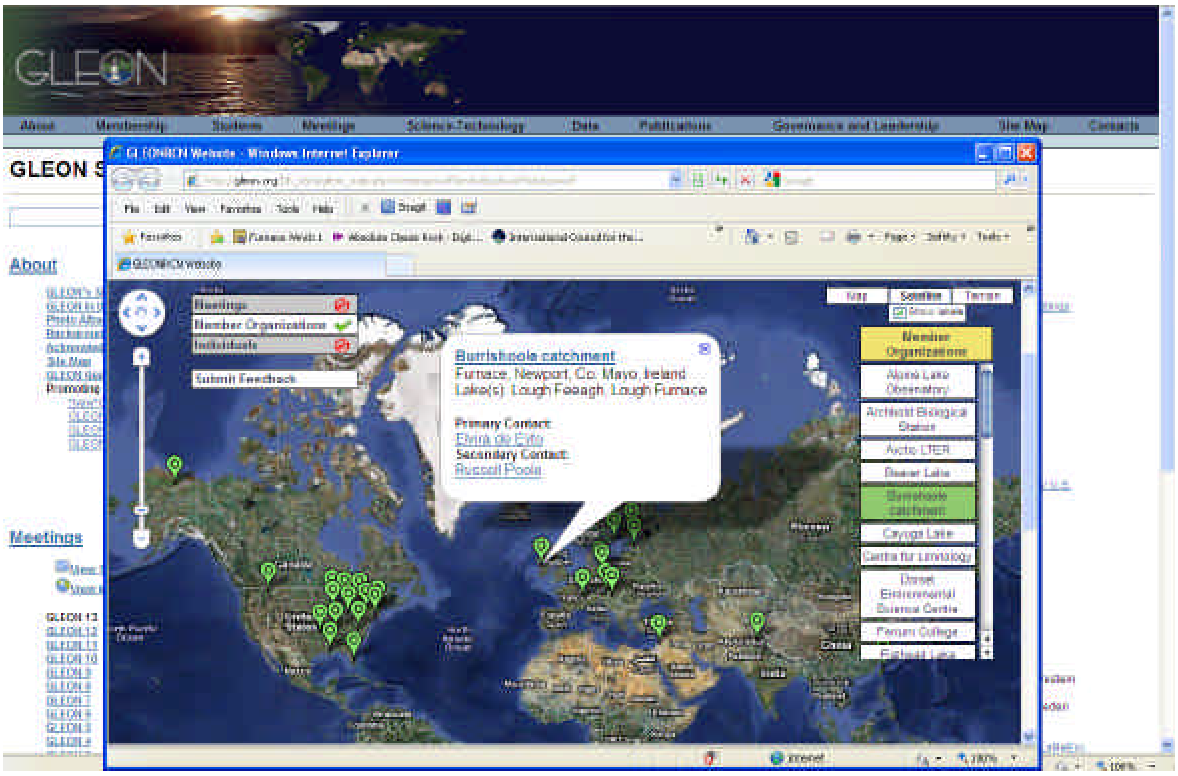
Peatlands are estimated to be one of the largest stores of carbon, storing 20-25 % of the earth soil organic carbon. Lakes in peat catchments receive high levels of humic substances from the catchment. In recent years, increases in carbon concentrations, specifically dissolved organic carbon (DOC) in streams, rivers and lakes in catchments draining peatlands in Europe and North

America, have been observed and may indicate a destabilisation of peatland carbon stores. An increase in DOC export from these stores has major implications for carbon cycling in humic lakes and also for drinking water resources. Humic lakes play an important role in carbon cycling, due to the high bacterial respiration and burial of organic carbon in sediment. The overall aims of this study by ***Liz Ryder, Dundalk IT,*** were to investigate carbon cycling in a humic lake using both high frequency and low frequency data, to quantify the main carbon pools in the lake, and to identify the drivers of temporal variation in these pools. An investigation of temperature quenching of in-situ fluorometers found that the level of temperature quenching of Chromophoric Dissolved Organic Matter (CDOM) fluorescence varied both over time and for sites. Not accounting for this effect was estimated to result in the underestimation of DOC concentration by approximately 30 % in a river and 5 % in a lake site. The results of the study of the carbon sources highlighted the key role of allochthonous carbon in the lake and the sensitivity of carbon export and in-lake carbon pools to climate. Using high resolution monitoring equipment estimates of annual loads of 9.5 t DOC km^2 $year^{-1}$ and 6.2 t POC km^2 $year^{-1}$ were exported from the catchment to Lough Feeagh. Soil temperature, river discharge and drought explained 59.7 % the deviance in DOC concentrations, while soil temperature, river discharge and rainfall were significant drivers of variation in POC concentrations, explaining 58.3 % of deviance. Within the lake, CDOM levels and buoyancy frequency, a measure of water column stability, explained 48 % of variance in 2010, while water temperature and wind speed explained 47 % of variance in phytoplankton biomass in 2011. An assessment of the contribution of allochthonous and autochthonous carbon pools to available carbon in the lake confirmed the role of allochthonous carbon in fuelling zooplankton production. In addition, the burial of carbon in the sediment in Lough Feeagh was high and was estimated to be 593.6 t $year^{-1}$ or 151.4 g C m^2 $year^{-1}$. The components of this research finally enabled a carbon budget to be produced for a humic lake in the west of Ireland.

Liz also received funding support from the Marine Institute RIM funding to attend the SIL meeting last August 2013.

9.3 GLEON

In 2007, the Burrishoole catchment became a member of the Global Lake Ecological Observatory Network (GLEON: http://www.gleon.org), an association of limnologists, information technology experts and engineers whose goal is to establish a persistent network of lake ecology observatories (http://www.gleon.org). Work with GLEON working groups continued in 2013, and the Marine institute was represented at GLEON 15 in Argentina by Elizabeth Ryder (DkIT and Marine Institute postgraduate researcher). A paper describing lake respiration around the globe was published by the GLEON metabolism working group (Solomon *et al.* 2013). Data from Lough Feeagh was one of 24 lakes included in the analysis. Another active GLEON area in 2013 was the inclusion of Lough Feeagh data into initial test runs of an open source, collaboratively coded 1-D lake model, GLM (General Lake Model).



9.4 NETLAKE

Following an initial kick-off meeting in late 2012, the Cost-ACTION NETLAKE project began work in earnest in 2013 (www.dkit.ie/netlake). Cost action projects are funded by the EU to provide networking opportunities for scientists in specific research areas. The aim of the NETLAKE action is to build a network of sites and individuals that will support the use of sensor-based systems in lakes and reservoirs and promote the use of these systems to address current and future water quality issues. The Marine Institute (represented by Elvira de Eyto and Russell Poole) are on the management committee of NETLAKE. In 2013, meetings were held in Dundalk in February and in Budapest in June. In addition, EdeE attended a workshop at Lake Erken, Sweden. Active areas of work included the development of a metadatabase to capture the network of sites in Europe with automatic lake monitors, and establishing community outreach projects with networked lakes.

9.5 Other

An informal collaboration with NINA in Trondheim in Norway came to fruition in 2013, with the publication of a paper describing methods aimed at improving electrofishing estimates of fish stocks (Hedger et al. 2013)

The outputs from the RESCALE project (Fealy et al., 2014) continue to be used by the catchment team, and the protocols and procedures developed during that collaborative research project are being implemented while collecting long term data in the catchment.

A detailed history of the development of Lough Furnace was published in 2013 (Cassina *et al.* 2013) based on some of the results of Filippo Cassina's PhD project (completed in 2012). This paper provides an excellent baseline against which the dynamics of Lough Furnace can be measured in the future.

10 Catchment Stock Assessment

10.1 Introduction

The Burrishoole catchment, upstream of the main fish traps, has been monitored since 1990 with surveys of the salmonid and eels stocks taking place in the rivers and the main lakes. Electrofishing, with 3-fishing depletions, is used for salmonids and eels in the streams, fine mesh beach seines are used for salmonids in the lakes and summer fyke nets are used for eels in the lakes. Eel surveys are also undertaken in the tidal waters below the traps

10.2 Electrofishing Surveys

2013 marked the completion of 23 years of electrofishing surveys in the Burrishoole and Owengarve catchments. Densities of eels and juvenile salmonids were calculated using three pass removal sampling.

In 2013, 43 sites in the Burrishoole and Owengarve catchments were fished between the 7th August and the 29th September. 4190 fish were caught and measured over the 43 sites. The 43 sites comprised 6365m^2 of representative habitat. Summary data are presented in Figures 10.1-10.6, and these show the distribution of fish densities around the catchment for eel (Fig. 10.1), 0+ salmon (Fig. 10.2), 1+ salmon (Fig. 10.3), 0+ trout (Fig. 10.4), 1+ trout (Fig. 10.5) and 2+ trout (Fig. 10.6).

The average eel density was 0.015 fish/m^2, with eels recorded in 24 sites out of 43. High densities were recorded in the Owengarve River as well as one site on each of the Maumaratta, Fiddaunnohoilean and Goulaun rivers.

Average density of 0+ salmon was 0.37fish/m^2, with catches recorded in 31 sites. Highest densities were recorded in the Goulaun, Lodge and Rough rivers, where densities exceeded 1 fish/m^2. The highest density recorded was 3.8 fish/m^2, which occurred at Rough site 11 (below the junction with the Lodge River).

1+ salmon were recorded in 29 sites, with an average density of 0.07 fish/m^2. The Goulaun River generally had high densities of 1+ salmon, along with the bottom site on the Maumaratta river.

Average densities of 0+, 1+ and 2+ trout were 0.30, 0.11 and 0.009 fish/m^2 respectively. 0+trout were recorded in all 43 sites, while 1+ and 2+ trout were recorded in 40 and 29 sites respectively.

As the survey was being carried out in 2013, it was noted that fish numbers were high. Certain sites had higher than normal fish densities for some age classes, and the number of fish per m2 increased between 2012 and 2013 for eel and salmon (Fig. 10.7).

10.3 Beach Seine Surveys

Beach seine surveys were conducted in 2013. The data were included in the survey database for future analysis

10.4 Fyke Net Surveys

10.4.1 Survey Data

Fyke net surveys of yellow eels have been conducted in the 1970s and 1980s as parts of previous studies. The Burrishoole lakes Feeagh and Bunaveela have been incorporated into the National Eel Survey in 2009-2012. Fyke net surveys of the tidal Lough Furnace and 'Back of the House' have been more sporadic or at a lower effort.

Yellow-eel stock monitoring is integral to gaining an understanding of the current status of local stocks and for informing models of escapement. Such monitoring also provides a means of evaluating post-management changes and forecasting the effects of these changes on silver eel escapement. The monitoring strategy aims to determine, at a local scale, an estimate of relative stock density, the stock's length, age and sex profiles, and the proportion of each length class that migrate as silvers each year.

Fyke net surveys carried out between 1960 and 2008 will provide a useful bench mark against which to assess the changes in stock. The yellow eel monitoring strategy will rely on the use of standard fyke nets. Relative density will be established based on catch per unit (scientific-survey) effort.

Bunaveela Lough is located in the upper reaches of the catchment. It has a surface area of 42ha and a maximum depth of 23m. Bunaveela L. was fished in the traditional style (sets of 10 nets perpendicular to the shore) in 2013 (4 July 2013), with chains of 10 nets fished at three sites (A, B, C). In total 15 eels were caught with a catch per unit of effort of 0.5 eels/net/night (Table 10.1). The eels average length was 45.8cm and ranged in length from 37.8cm to 57.5cm. All eels were PIT tagged.

Lough Feeagh has a surface area of 395ha and an average depth of 14.5m (with several areas >35m in depth). L. Feeagh was fished in the traditional style (sets of 10 nets perpendicular to the shore) in 2013 (10-11 July 2013), with chains of 10 nets fished at six sites (A, C, D, E, F, J) for one night each. In total, 96 eels were caught with a catch per unit effort (CPUE) of 1.6 eels/net/night (Table 10.1). The eels average length was 40.3cm and ranged in length from 31.3cm to 93.2cm, with a total weight of 13.64kgs caught in the two nights. Most of the catch was PIT tagged and two previous recaptures were taken.

Lough Furnace, the tidal lough, has a surface area of 125ha north of Nixon's Island and 16ha between Nixon's Island and the mouth of the estuarine river ('Back of the House'). The main lough has a maximum depth of 21.5m. Furnace is heavily stratified with significant areas of deoxygenated water in the main basin. L. Furnace was fished in the traditional style (sets of 10 nets perpendicular to the shore) in 2013 (17-18 July 2013), with chains of 10 nets fished at six sites

(A, B, C, D, E, F) in one night each and one night (25 July 2013) with two chains of nets at the Back of the House which is a shallow tidal area between the lough and the estuarine river.

In L. Furnace, 145 eels were caught with a catch per unit effort (CPUE) of 2.4 eels/net/night (Table 10.1). The eels average length was 43.1cm and ranged in length from 29.1cm to 73.0cm, with a total weight of 21.82kgs caught for the 2 nights (Table 10.1).

In the Back of the House, 54 eels were caught with a catch per unit effort (CPUE) of 2.7 eels/net/night (Table 10.1). The eels average length was 45.3cm and ranged in length from 29.8cm to 77.8cm, with a total weight of 10.45kgs caught.

Table 10-1: Catch details of the yellow eel survey carried out in 2013.

Lake	Dates	No. Eels	Net* Nights	CPUE	Total weight (kg)	Mean length (cm)	Mean weight (kg)
Bunaveela**	04/07/2013	15	30	0.5	2.80	45.8 (37.8-57.5)	0.187
	2013	**15**	**30**	**0.5**	**2.80**	**45.8 (37.8-57.5)**	**0.187**
Feeagh	10/07/2013	64	30	2.1	9.55	40.5 (31.3-93.2)	0.149
	11/07/2013	32	30	1.1	4.09	40.0 (32.0-62.5)	0.128
	2013	**96**	**60**	**1.6**	**13.64**	**40.3 (31.3-93.2)**	**0.142**
Furnace	17/07/2013	76	30	2.5	10.79	42.3 (29.1-73.0)	0.142
	18/07/2013	69	30	2.3	11.04	43.9 (30.3-66.3)	0.160
	2013	**145**	**60**	**2.4**	**21.82**	**43.1 (29.1-73.0)**	**0.150**
BOH	25/07/2013	54	20	2.7	10.45	45.3 (29.8-77.8)	0.194
	2013	**54**	**20**	**2.7**	**10.45**	**45.3 (29.8-77.8)**	**0.194**

* Net (pair of traps)

** estimated from lengths

10.4.2 *Anguillicoloides crassus*

Anguillicoloides crassus is an indigenous parasitic nematode of the Japanese eel *Anguilla japonica* in Asia. *A. crassus* does not cause serious pathological damage in its natural host. However, infections in European eel are potentially more serious and can cause damage to the swimbladder with associated bacterial damage, red and swollen anus, as well as, in most severe cases, the collapse of the swimbladder lumen.

A. crassus was introduced into Europe in the early 1980s and it has since spread widely and has successfully colonized most European countries. It was first recorded in Ireland (Waterford Harbour) in 1997. Later records came from the Erne catchment in 1998 and it is now present in approximately 74% of the wetted area of Ireland. The most likely infective route to Ireland was the commercial eel trade although localised spread can be through natural eel movements and paratenic hosts.

The Burrishoole catchment remained free of the parasite until recently. In the fyke net survey in 2012, samples of yellow eels captured in L. Furnace (saline) and at the Back of the House (tidal lough below L. Furnace) were found to be infected with *A. crassus*. Samples of yellow eels from L. Feeagh were negative and a comprehensive sample of silver eels from the traps was also negative indicating that in 2012 the infection seemed to be confined to the tidal lough. This was somewhat surprising as a number of environmental factors have been shown to influence *A. crassus* infections. High salinity has been shown as having a negative impact in the egg hatching and larvae survival of the parasite although the effects of water salinity remain unclear as various surveys have shown no differences in infection levels in waters with different salinity values.

Examination of previous samples would indicate that the parasite was likely to have been introduced into L. Furnace in 2010 or early 2011 (Table 10.2).

The infection intensity in L. Furnace eels continued to rise in 2013. To date it has not been recorded in the freshwater catchment.

Table 10-2: Location and sample details for eels in Burrishoole examined for the presence of *Anguillicoloides crassus*.

Year	Location	No. of eels checked	Stage	No. Infected	Prevalence	Intensity
Freshwater						
2009	Traps	50	Silver	0	0	0
2010	Yellow R.	5	Yellow	0	0	0
2010	Black Lakes	3	Yellow	0	0	0
2010	Glenamong R.	3	Yellow	0	0	0
2010	Feeagh	2	Yellow	0	0	0
2010	Traps	17	Silver	0	0	0
2011	Traps	50	Silver	0	0	0
2011	Feeagh	30	Yellow	0	0	0
2012	Feeagh	4	Yellow	0	0	0
2012	Traps	168	Silver	0	0	0
2013	Traps	106	Silver	0	0	0
Saline Water						
2008	Furnace	60	Yellow	0	0	0
2009	Fu Nixons	47	Silver	0	0	0
2010	Furnace	10	Yellow	0	0	0
2010	Fu Nixons	50	Silver	0	0	0
2011	Furnace	4	Yellow	2	50	1.0
2012	BOH	6	Yellow	6	100	2.0
2012	Furnace	10	Yellow	7	70	4.43
2013	Furnace	6	Yellow	6	100	13.5

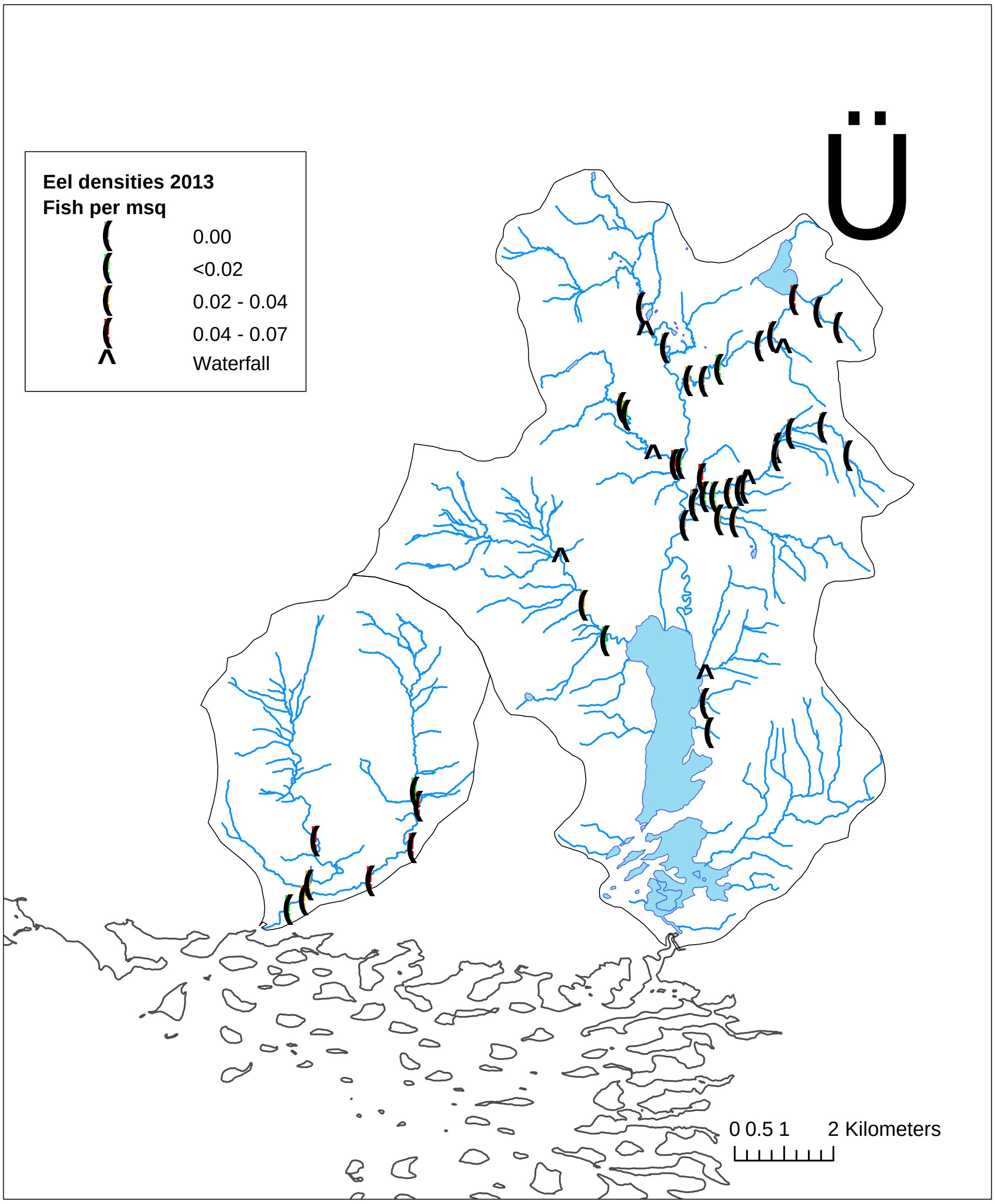


Figure 10-1: Densities of eel calculated from the 2013 electrofishing survey of the Burrishoole and Owengarve catchments.

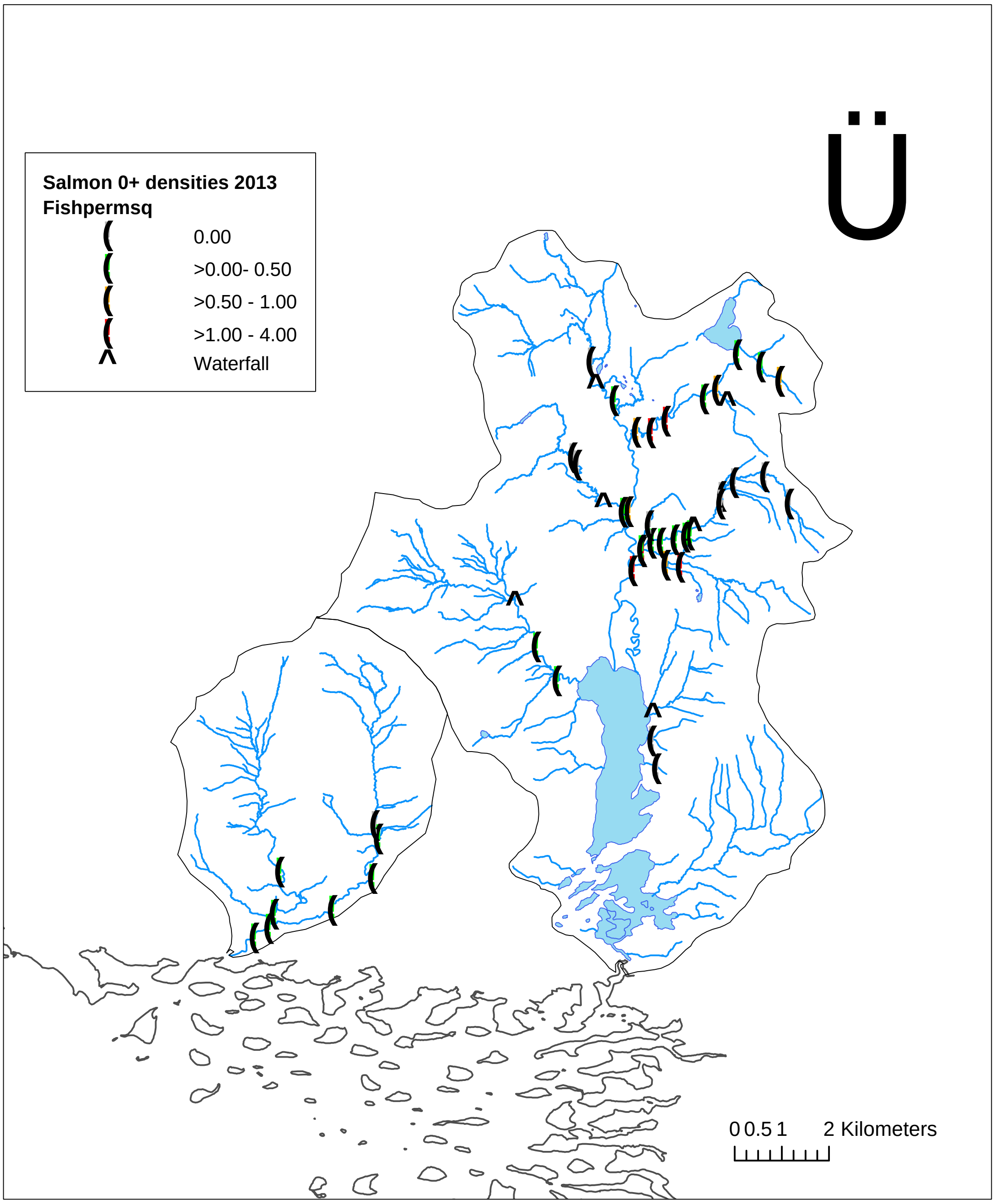


Figure 10-2: Densities of 0+ salmon calculated from the 2013 electrofishing survey of the Burrishoole and Owengarve catchments.

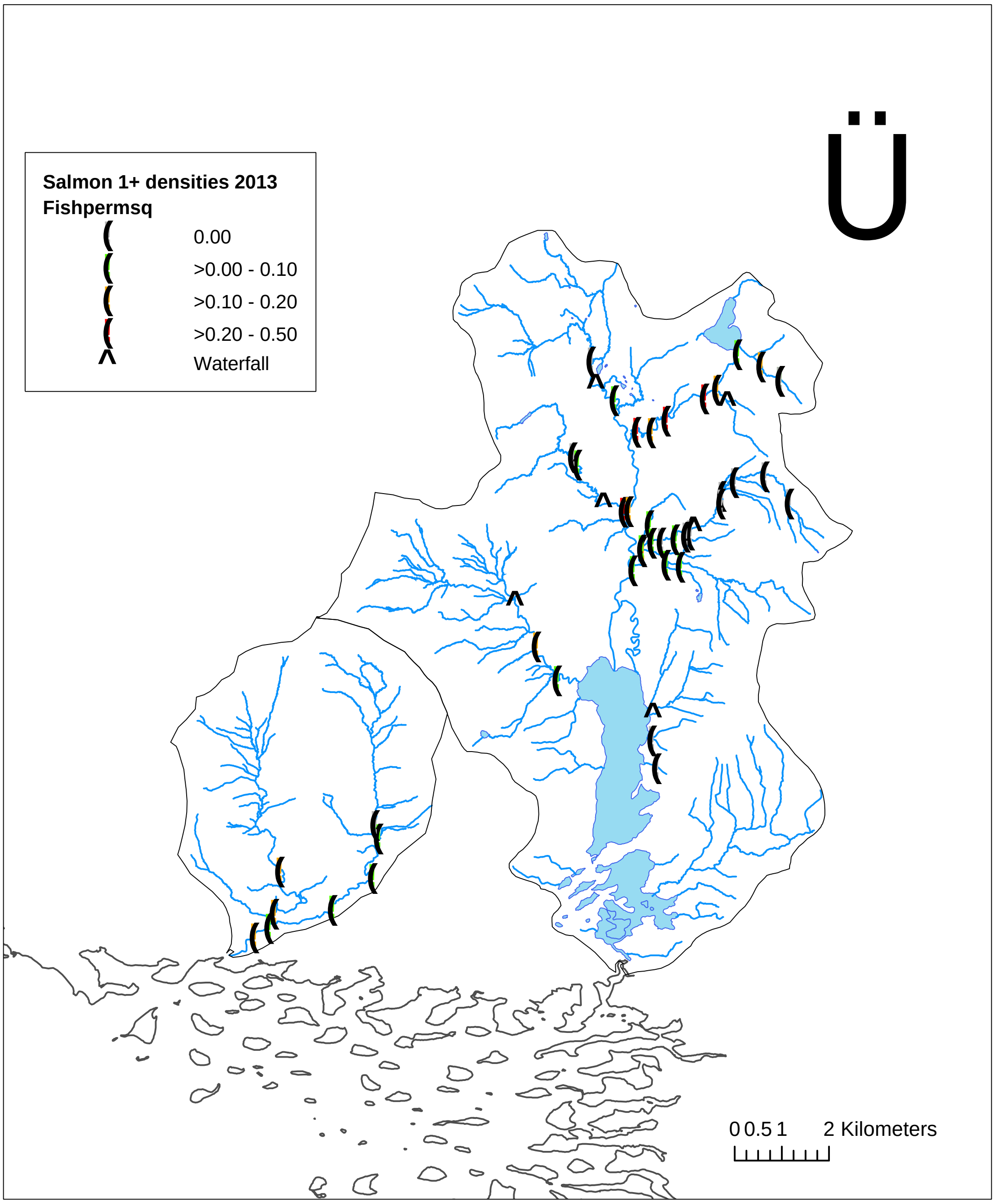


Figure 10-3: Densities of 1+ salmon calculated from the 2013 electrofishing survey of the Burrishoole and Owengarve catchments.

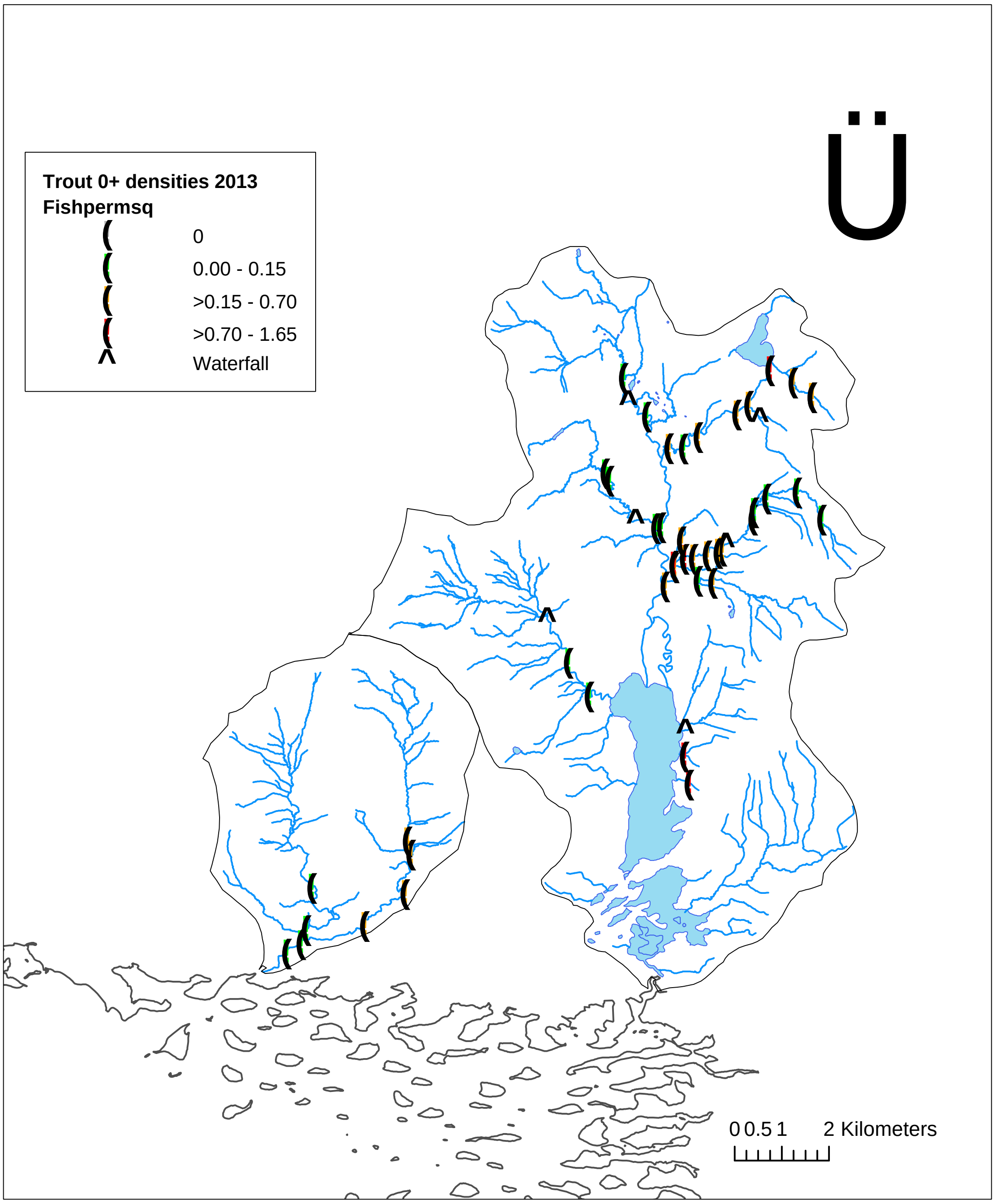


Figure 10-4: Densities of 0+ trout calculated from the 2013 electrofishing survey of the Burrishoole and Owengarve catchments.

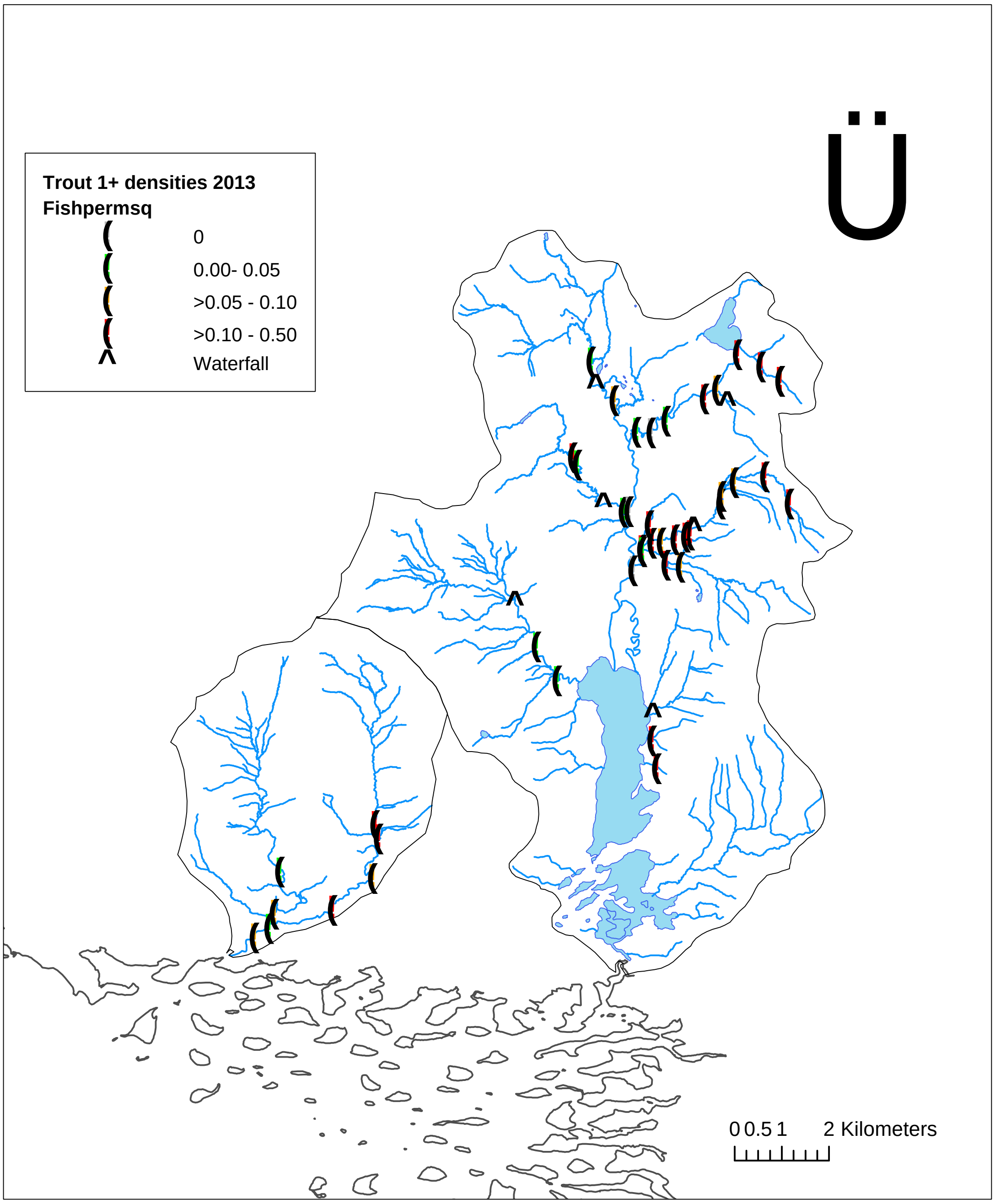


Figure 10-5: Densities of 1+ trout calculated from the 2013 electrofishing survey of the Burrishoole and Owengarve catchments.

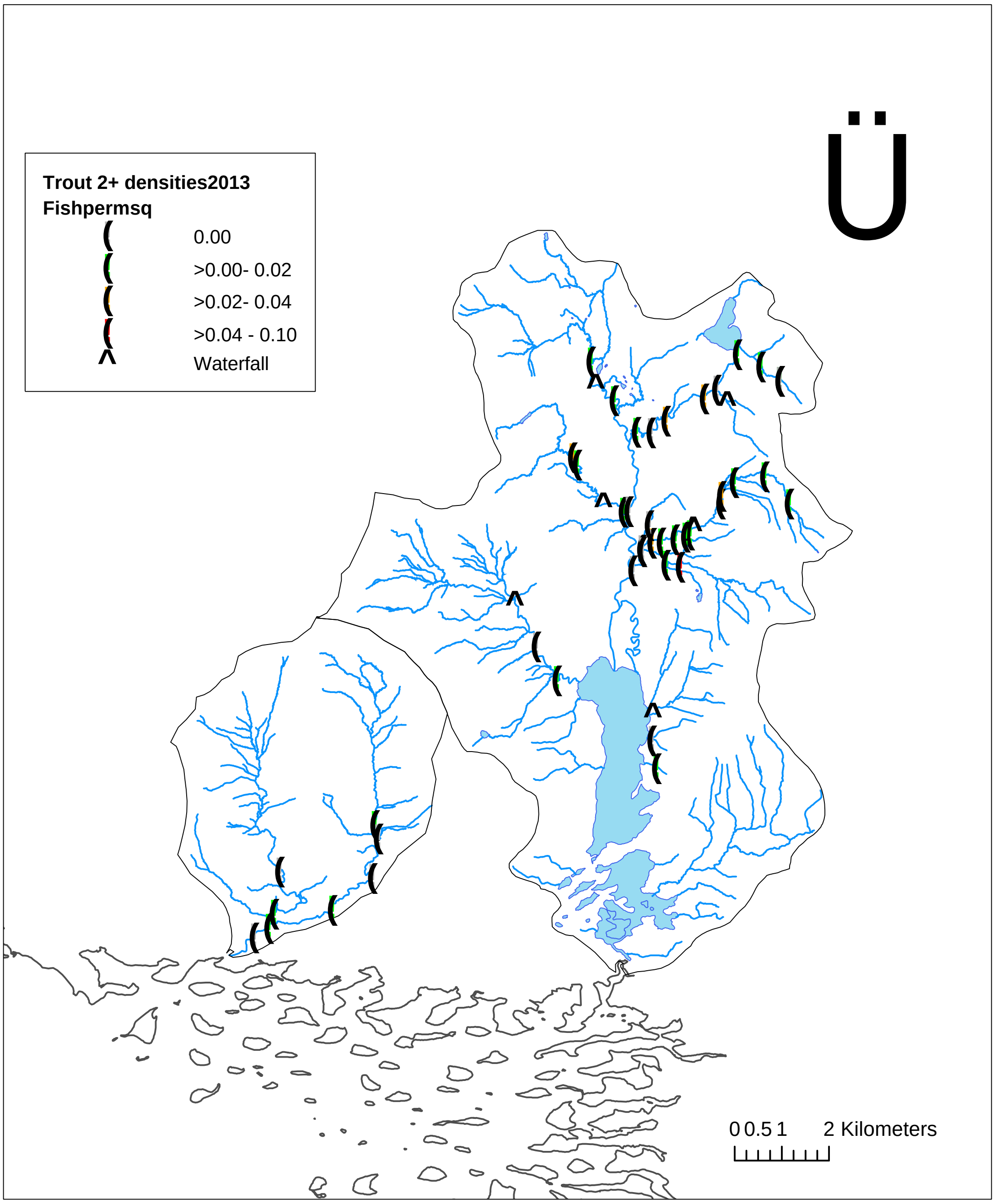


Figure 10-6: Densities of 2+ trout calculated from the 2013 electrofishing survey of the Burrishoole and Owengarve catchments.

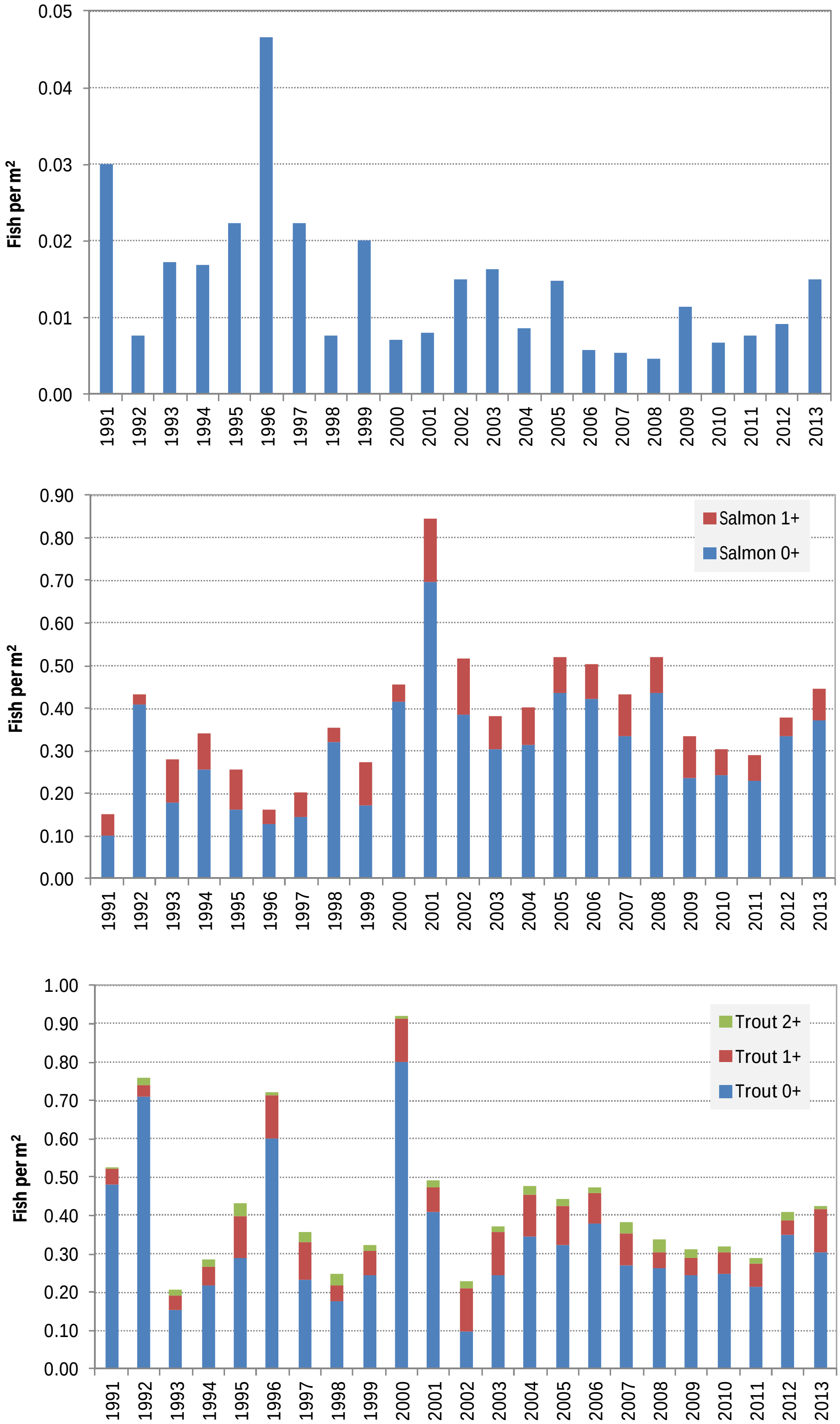


Figure 10-7: Average densities of eel, salmon and trout (fish per m²) calculated from electrofishing surveys of the Burrishoole and Owengarve catchments, 1991-2013.

10.5 Long-term biological monitoring in the Burrishoole catchment

Macroinvertebrate surveys of 16 index sites were conducted in 2013. 373 individuals from 48 samples were counted and identified, and are recorded in the Catchment Macroinvertebrate Access database for future analysis. Zooplankton and phytoplankton surveys of Feeagh and Furnace were continued in 2013, with monthly samples being collected using standard methods, and preserved for future enumeration and identification.

11 Publications

11.1 Peer-review

Bourret, V., Kent, M.P., Hayes, B.J., Primmer, C.R., Vasemagi, A., Karlsson, S., Hindar, K., McGinnity, P., Verspoor, E., Bernatchez, L. & Lien, S. (2013). SNP-array reveals genome wide patterns associated with geographical and potential adaptive divergence across the natural range of Atlantic salmon (*Salmo salar*). *Molecular Ecology* 22, 532–551.

Cassina, F., Dalton, C., de Eyto, E. & Sparber, K. (2013) The Palaeolimnology of Lough Murree, A Brackish Lake in the Burren, Ireland. *Biology & Environment: Proceedings of the Royal Irish Academy* **113,** 1-17.

Cassina, F., Dalton, C., Dillane, M., de Eyto, E., Poole, R., Sparber, K. (2013). A multi-proxy palaeolimnological study to reconstruct the evolution of a coastal brackish lake (Lough Furnace, Ireland) during the late Holocene. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 383-384:1-15.

Carlsson J, Gauthier D, Carlsson JEL, Coughlan JP, Dillane E, FitzGerald RD, Keating FU, McGinnity P, Mirimin L & Cross TF. (2013). Rapid, economical SNP and microsatellite discovery based on *de novo* assembly of a reduced representation genome in a non-model organism: a case study of Atlantic cod. *Journal of Fish Biology* 82, 944–958.

Ensing, D., Crozier, W.W., Boylan, P., O'Maoiléidigh, N. & McGinnity, P. (2013). An analysis of Genetic Stock Identification on a small geographical scale using microsatellite makers, and its application in the management of a Mixed-Stock fishery for Atlantic salmon (*Salmo salar* L.) in Ireland. *Journal of Fish Biology* 82 (6) 2080-2094.

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Jackson. J, Cotter, D., Newell, J., McEvoy, S., O'Donohoe, P., Kane, F., McDermott, T., Kelly, S. & Drumm, A. Impact of *Lepeophtheirus salmonis* infestations on migrating Atlantic salmon , *Salmo salar* L., smolts at eight locations in Ireland with an analysis of lice-induced marine mortality. *Journal of Fish Diseases* 2013 36(3):273-81.

Karlsson, S., Hagen, M., Eriksen, L., Hindar, K., Jensen, A.J., de Leaniz, C.G., Cotter, D., Guðbergsson, G., Kahilainen, K., Guðjo´nsson, S., Romakkaniemi, A., & Ryman, N. A genetic marker for the maternal identification of Atlantic salmon x brown trout hybrids. *Conservation Genetics Resources*, Volume 5,Issue 1, pages 47-49, 2013. DOI 10.1007/s12686-012-9730-6.

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Keenan, K., Bradley, C. R., Magee, J. J., Hynes, R. A., Kennedy, R. J., Crozier, W. W., Poole, R., Cross, T. F., McGinnity, P. & Prodöhl, P. A. (2013). Beaufort Trout MicroPlex: A high throughput multiplex platform comprising 38 informative microsatellite loci for use in brown trout and sea trout (*Salmo trutta* L.) population genetics studies. *Journal of Fish Biology*. 82 (6), 1789-1804.

O'Driscoll, C., de Eyto, E., O'Connor, M., Asam, Z.-u.-Z., Rodgers, M. & Xiao, L. (2013) Biotic response to forest harvesting in acidic blanket peat fed streams: a case study from Ireland. *Forest Ecology and Management* **310,** 729-739.

O'Farrell, B; Benzie, JAH; McGinnity, P; de Eyto, E; Dillane, E; Coughlan, J. & Cross, T (2013) Major histocompatibility class I variation in wild Irish brown trout (*Salmo trutta*). *PLoS ONE* 8(5): e63035.

Solomon, C. T., D. A. Bruesewitz, D. C. Richardson, K. C. Rose, M. C. Van de Bogert, P. C. Hanson, T. K. Kratz, B. Larget, R. Adrian, B. Leroux Babin, C.-Y. Chiu, D. P. Hamilton, E. E. Gaiser, S. Hendricks, V. Istvanovics, A. Laas, D. M. O'Donnell, M. L. Pace, E. Ryder, P. A. Staehr, T. Torgersen, M. J. Vanni, K. C. Weathers, and G. Zhu. (2013). Ecosystem respiration: Drivers of daily variability and background respiration in lakes around the globe. *Limnology and Oceanography* **58**: 849-866. **MI was a data provider**

Weathers, K C., P. C. Hanson, P. Arzberger, J. Brentrup, J. D. Brooks, C. C. Carey, E. Gaiser, D. P Hamilton, B. W. Ibelings, V. Istánovis, E. Jennings, B. Kim, T. K. Kratz, F. P. Lin, K. Muraoka, C. M. O'Reilly, C. Piccolo,

K. Rose, **E. Ryder** and G. Zhu. 2013. The Global Lake Ecological Observatory Network (GLEON): The Evolution of Grassroots Network Science. *Linmology and Oceanography*: Bulletin, 22: 70-98.

11.2 Grey Literature, Reports, Theses

Fealy, R., Allott, N., Broderick, C., de Eyto, E., Dillane, M., Erdil, R. M., Hancox, L., Jennings, E., McCrann, K., Murphy, C., O'Toole, C., Poole, R., Rogan, G., Ryder, E., Taylor, D., Whelan, K., White, J. 2014. RESCALE: Review and Simulate Climate and Catchment Responses at Burrishoole. Technical Report. Marine Research Sub-Programme (NDP 2007-2013) Series. 426 pp.

E. Ryder, E. de Eyto, M. Dillane, R. Poole and E. Jennings. Using a combination of high frequency and low frequency data to estimate carbon pools in a humic lake. 2013. GLEON 15, Bahia Blanca, Argentina.

E. de Eyto, E. Ryder, M. Dillane, E. Jennings. Lough Feeagh and Lough Furnace NETLAKE sites in Ireland. NETLAKE, Dundalk Institute of Technology, Co Louth, Ireland.